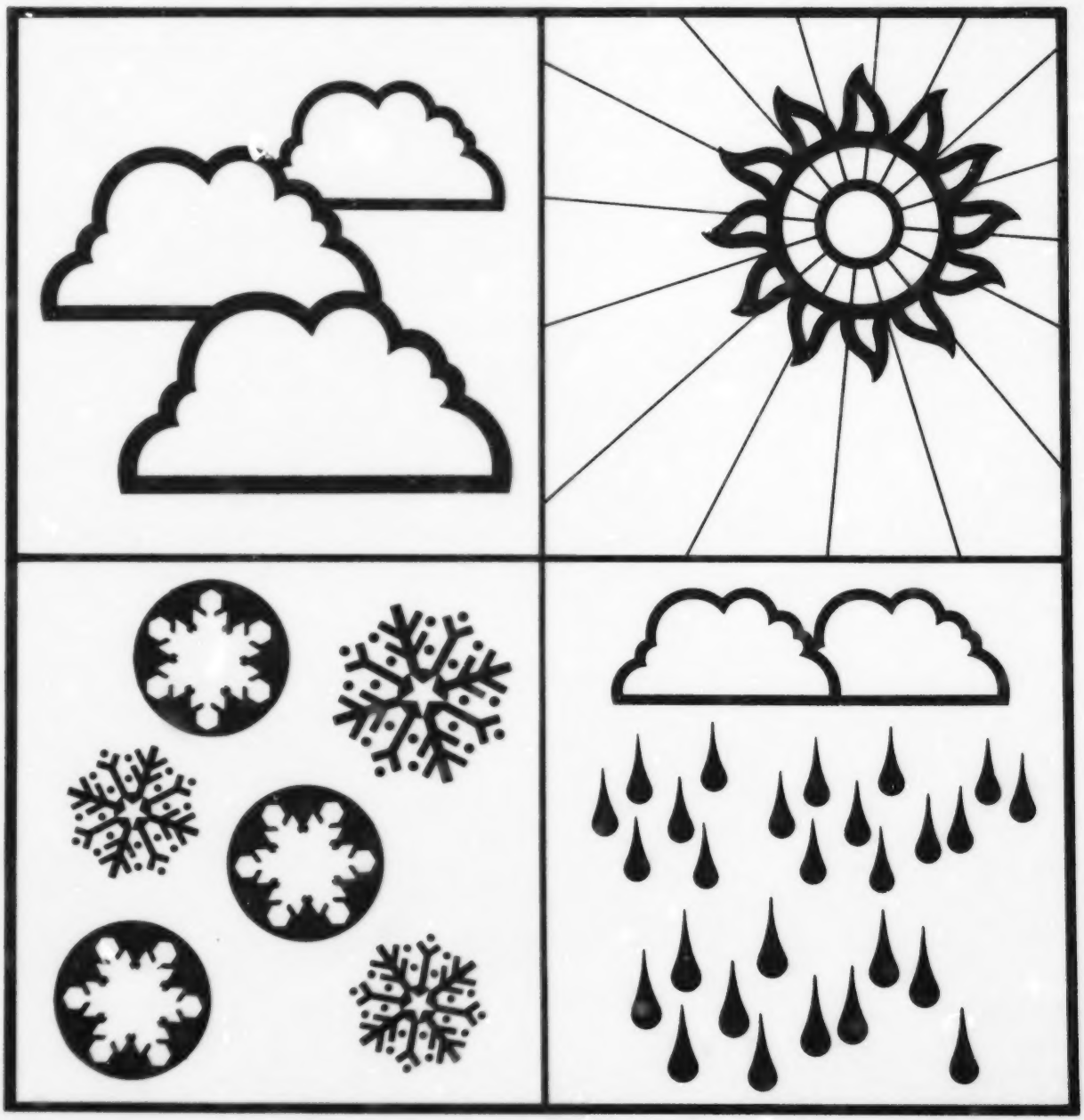
The Climate for Agriculture in Atlantic Canada



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THE CLIMATE FOR AGRICULTURE IN ATLANTIC CANADA

Prepared by:

P.A. Dzikowski, Nova Scotia Department of Agriculture and Marketing, Truro, Nova Scotia.

G. Kirby, Newfoundland and Labrador Dept. of Rural, Agricultural, and Northern Development, St. John's, Newfoundland.

G. Read, New Brunswick Department of Agriculture and Rural Development, Fredericton, New Brunswick.

W.G. Richards, Environment Canada, Atmospheric Environment Service, Bedford, Nova Scotia.

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THE CLIMATE FOR AGRICULTURE IN ATLANTIC CANADA

A. CLIMATE AND AGRICULTURE

The Atlantic region experiences a wide range of growing conditions. Coastal areas have a long but cool growing season, while sheltered inland valleys have a shorter but much warmer growing season. Areas which have warm summers can still experience very cold winters. The temperature at Fredericton, New Brunwick ranges from an extreme maximum of 39 C to an extreme minimum of -39 C. Whereas at the coastal location of Yarmouth, Nova Scotia, the extreme maximum is 30 C and the extreme minimum is -21 C, a much narrower temperature range. Such variation in climate requires crop selection and management practices suited to the climate and soil conditions of the location.

The diversity of climate within this small region of Canada is reflected in the variety of crops produced here. High quality potato production for seed and tablestock returns many dollars to the Atlantic economy. Apples, strawberries and blueberries provide a high quality product for the fresh market and the processors with a wide selection of produce. Cereal grain production for livestock feed and for the milling market is increasing.

The growing season in the Atlantic region is characterized by a cool wet spring, a warm summer with ample rainfall, but with occasional dry periods, and a cool wet autumn. The long cool growing season and ample rainfall favour perennial forage production. The cool spring with generally high rainfall combined with heavy imperfectly drained soils, common in the region, creates field trafficability problems which delay spring field work and seeding. Delayed seeding means the crop is losing the benefit of any early warm spring days. Technological innovations, such as using small tractors with wide, high flotation tires for early seeding, and growing overwintering annuals, provide ways of using the entire growing season available. A late-planted crop risks not reaching maturity or its maximum yield potential before fall frosts threaten. Late seeding also delays harvest to a time when high rainfall can once again cause field trafficability problems.

The growing season for frost sensitive crops is determined by the last spring frost and first fall frost. The frost-free period varies a great deal depending upon latitude, elevation, topography, and proximity to large water bodies. The frost-free period in Atlantic Canada is generally adequate for vegetable crops, however, heat-loving long season crops such as tomatoes are limited to a very few locations. Although coastal locations have long frost-free periods they do not have the high temperatures required for the rapid growth and maturity of warm season crops. The advent and use of plastic mulches and tunnels has altered the microclimate of the crop to provide sufficient heat for crops such as peppers, melon and eggplant to reach maturity.

There are insufficient corn heat units within the frost-free period to produce high quality grain corn, except for the earliest hybrids grown in a few select areas. However, corn is regularly grown for silage in the select areas with sufficient corn heat units. The breeding of earlier maturing hybrids is making grain corn a more promising prospect as a source of livestock feed in Atlantic Canada. There has also been some success with early maturing soybeans in high heat unit areas.

Winter temperatures in the region can dip low enough to cause damage, but a good snow cover can prevent cold temperatures from being a problem. Atlantic Canada is exposed to the coldest of weather from the Arctic and also the warmest of weather from the south. This situation creates frequent freeze-thaw cycles and reduces the dependability of snow cover. Usually the transitions from cold to warm and back again are gradual enough to not be a problem. But winter injury to tree fruits, perennial forages, and overwintering cereal grains is a constant hazard to be minimized by careful site selection, variety selection and management.

An increasing land base is being devoted to growing high quality livestock feed. This means selecting new crops or new hybrids to produce both quantity and quality feedstuffs. Consideration of climatic resources such as heat units, frost-free period, workday probabilities, and harvesting hours will help ensure a successful cropping program, and a profitable livestock industry. This publication is intended to provide a climatic planning tool for the agricultural community. Consideration of long term climatic averages and extremes is essential for the successful introduction of new crops, new varieties, new hybrids, and the expansion of production into new areas.

B. CLIMATE IN GENERAL

Weather and climate dictate what crops can be grown in a region and are mainly responsible for the yearly variation of yields. The difference between weather and climate is the rain, sun, heat, cold, or winds which happen now, while the climate is the long term average describing what generally happens.

There are four factors which determine the climate of a place;

I) Position on the globe,
II) Wind systems,
III) The ratio of water to land, and
IV) Topography.

The biggest impact on climate is latitude, how far north or south you are on the globe. Both the sun's radiation and wind circulation patterns change with latitude.

The sun's influence on climate is the most basic and the easiest to understand. Because of the spherical shape of the earth, the sun's rays heat the earth more at the equator than at the poles. The equatorial regions do not grow continually hotter and the polar regions continually colder because, periodically, large masses of hot air move north and cold air masses move south to maintain heat balance.

If latitude was all that counted, cities and countries at the same latitude would have identical climates, but they don't. The next two factors, wind systems, and the relationship of water to land, come into play.

The general wind circulation in the atmosphere results from nature's maintenance of the overall heat balance of the earth. As the large tropical and arctic air masses, usually measuring several hundreds of kilometers across, try to move north and south, the rotation of the earth deflects the wind in an easterly direction. The result is a wide belt, in the mid-latitudes of the northern hemisphere, known as the zone of the westerlies, so-called because that is the direction from which the wind blows.

The interaction of the prevailing westerly winds with water, and its relation to land, in determining climate is demonstrated by the different climates of Canada's east and west coasts. The westerlies blow sea air onshore - mild air in winter and a cool air in summer- to give British Columbia its moderate mild climate. In the Maritimes, the prevailing westerlies blow offshore, giving the east coast a more extreme climate and one more similar to that of inland Canada.

Oceans act as huge storage areas for heat. They absorb it in spring and summer, then release it in fall and winter. The oceans also transmit heat and cold around the world in the form of great ocean currents such as the Gulf Stream or the Labrador Current. Such currents give areas higher or lower temperatures than they would otherwise have.

The fourth major factor influencing climate is topography. Mountain ranges can force air masses to rise and drop their moisture, creating wet conditions on one side and a drier climate on the other. Mountain ranges can also direct the motion of air, so that it moves parallel to the mountains. On a smaller a scale, valleys have very different climates from surrounding level areas.

C. CLIMATE OF ATLANTIC CANADA

The influence of the prevailing westerlies is responsible for bringing air from the interior of the continent to the Atlantic region. However, air masses ranging from the Arctic to the Gulf of Mexico may end up over Atlantic Canada. Many of the migratory low pressure systems moving across North America pass over the Atlantic provinces because of the prevailing westerlies. As a result, this region has storms more frequently throughout the year than any other part of the country. The frequent passing of low pressure areas, with their associated bad weather, and the maritime location provide Atlantic Canada with ample precipitation.

Despite the maritime location of the Atlantic provinces the climate is a modified continental type. A continental climate is characterized by a wide range of temperature. A maritime climate is characterized by a reduced temperature range because the ocean supplies heat in winter and provides cooling in summer. Areas near the coast have milder winters and cooler summers, with a longer frost-free period than inland locations. However, the advantage of a prolonged season is offset by the cooler temperatures and fewer heat units available for plant growth.

The wind direction and the relationship of land to water is a major factor determining climatic differences within the region. The southern coasts of New Brunswick, Nova Scotia, and Newfoundland have the highest annual precipitation in Atlantic Canada due to south-easterly storm winds blowing moisture laden air onshore. In contrast the Northumberland coasts of New Brunswick and Nova Scotia, all of Prince Edward Island, and northern Newfoundland are in a "rain shadow". This means that south-easterly storm winds have already dropped most of their precipitation by the time they reach these areas and precipitation amounts are reduced.

Coastal waters differ in the influence they have on the climate of adjoining land. The warm waters of the Gulf of St. Lawrence and especially the Northumberland Strait, do not provide as much cooling in summer as do the cool waters of the Atlantic. In winter the Gulf waters are frozen and do not provide the warming the Atlantic Ocean does. For this reason the Gulf waters are less effective in moderating the climate of Prince Edward Island, eastern New Brunwick, northern Nova Scotia, and western Newfoundland.

The greatest moderating effect of the Atlantic is seen in southeastern Newfoundland, western Nova Scotia, and southern New Brunswick. The cold Labrador current curving around Newfoundland's Avalon peninsula makes this the coolest part of the province in summer and the mildest in winter. This same but weakened current has a similar but reduced effect on the southeast coast of Nova Scotia.

The Bay of Fundy and the Lurcher marine area west of Nova Scotia provide strong moderation of air temperature over southern New Brunswick and western Nova Scotia in both summer and winter. The reason for this is the tidal mixing of these waters. When water is heated it forms layers of different temperature with the warmest on top. When it is cooled it also stratifies but with the coldest on top. If the water is well mixed it does not form layers. Well mixed waters are colder in summer and warmer in winter than other coastal waters, making them more effective in reducing summer temperatures and warming winter temperatures.

i. Measuring The Weather

There are two basic types of weather stations in Atlantic Canada. The first is a synoptic station which is staffed by the Atmospheric Environment Service of Environment Canada. Detailed observation of weather conditions are reported hourly, and that information is used to forecast the weather. The second is a climatological station. The observers, who are volunteers or staff of cooperating agencies such as Agriculture Canada, record temperature and precipitation amount daily. At some stations only one of the parameters is recorded.

In 1984, there were 38 synoptic and 195 climatological stations in Atlantic Canada. Without the dedicated service of the many volunteer observers in the region, this publication would not be possible.

Air temperature is measured by an ordinary thermometer situated 1.2 m above the ground in a louvred shelter, called a Stevenson Screen. The shelter protects the thermometers from the direct sun, precipitation and heat radiation from the ground. The maximum and minimum temperature are recorded for each day. Rainfall is collected in a calibrated

container and recorded daily. Snowfall is measured at several locations by a ruler, some of the other parameters measured at a few locations across the province include; windspeed and direction, relative humidity or dew point, visibility, cloud cover (amount and type), evaporation, atmospheric pressure, and solar radiation or hours of bright sunshine.

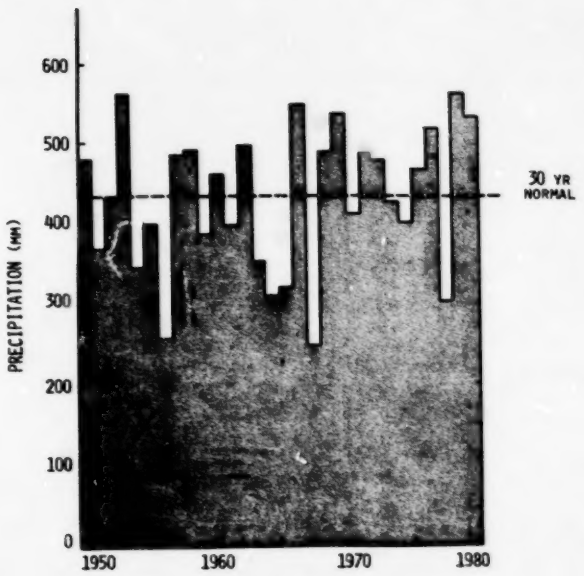
ii. Climatic Normals

A long period of weather observations is necessary to understand the expected variety of weather on the average. The term "Climate Normals" is used to describe the average data for a 30 year period. A 30 year period is usually used because it is long enough to filter out short term fluctuations, but is not overridden by any long term trend in the climate.

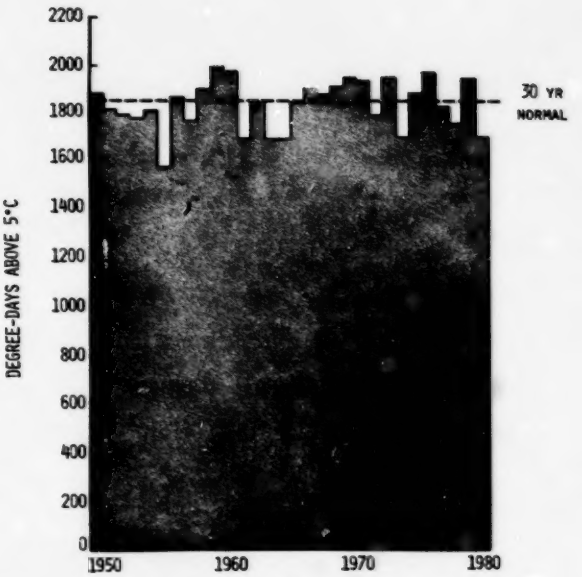
Climatic normals provide monthly averages for the many parameters observed. The ones most often used in agriculture are precipitation, temperature, sunshine hours, information derived from temperature, such as degree-days or frost dates, and one which combines many factors, evapotranspiration. This sort of information is used as a long term planning tool, either to select a location for a farm, or to plan a cropping program. The average is sometimes not adequate for planning because often it is the extreme event which can be disastrous. For this reason, extremes for the entire period of record, that is as long as observations have been recorded at the site, are given.

Caution must be exercised when dealing with extremes, because the period of record is very important. The shorter the period of record, the less reliable the extreme. If you want to know how much snow was dropped by the worst storm in a hundred years, you can't expect a station with only 20 years of record to provide it. The shorter the period of record the more likely it is that a unique extreme event has been missed.

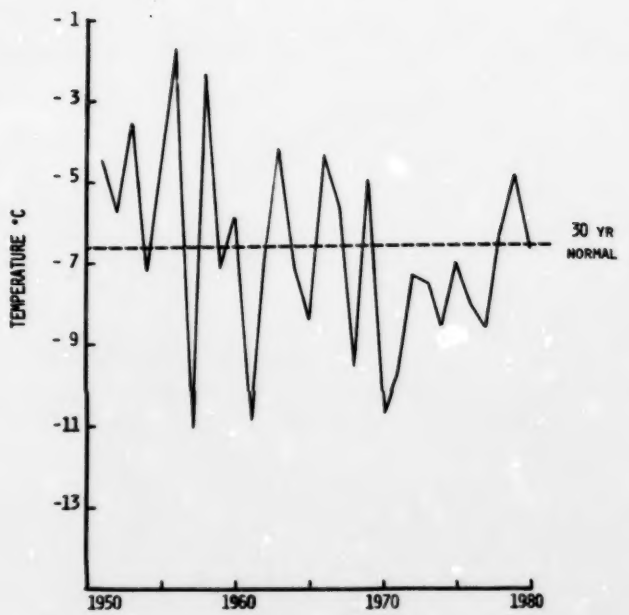
It is also important, when using climatic normals, to recognize that they represent the average of widely varied yearly values which occurred over the 30 year period. Some examples of the year to year variations which occur are presented in Figures 1 to 4. The dotted line across each figure is the "normal" or 30 year average around which the actual yearly values vary. When evaluating crop performance in any given year it is important to know whether the year was near normal, above normal or below normal, so you can judge whether the season was typical or not. This information can help minimize the risk when establishing a cropping program.



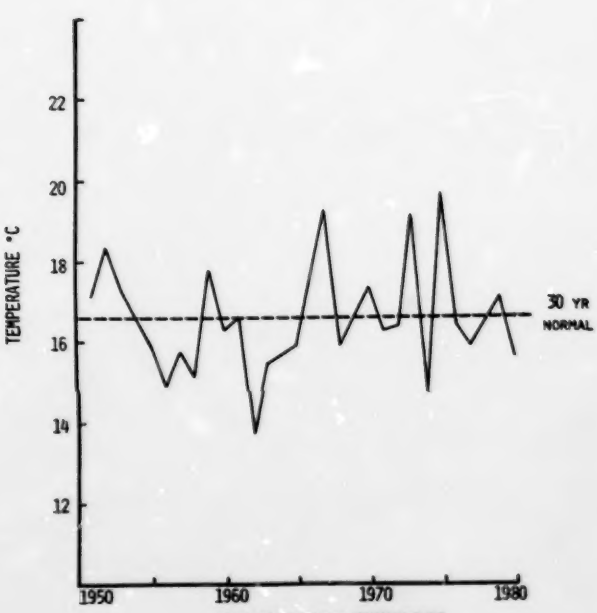
MAY-SEPTEMBER TOTAL PRECIPITATION (mm)
AT FREDERICTON, NB 1951-1980



ANNUAL DEGREE-DAYS ABOVE 5°C
AT KENTVILLE, NS 1951-1980



JANUARY MEAN DAILY TEMPERATURE
AT CHARLOTTETOWN CDA, PEI 1951-1980



JULY MEAN DAILY TEMPERATURE
AT DEER LAKE, NFLD 1951-1980

The information presented in these climatic maps is based on the Canadian Climate Normals, 1951-80:

- Temperature and Precipitation, Atlantic Provinces;
- Degree-Days (Vol.4);
- Frost (Vol.6); and
- Bright Sunshine (Vol.7);

published by the Canadian Climate Program, Atmospheric Environment Service, Environment Canada.

The data for the growing season (maps 6 to 8A) was derived by fitting a straight line to the published monthly mean temperatures of the four months in the spring and the four in the fall, then obtaining the date at which 5 C occurred.

iii. Degree-Days (Heat Units)

Temperature affects plant processes mainly by controlling the rate of growth. The concept of growing degree-days, or heat units, assumes that the plant growth is related directly to the average temperature. There are certain minimum temperatures below which plants do not grow. For perennial plant growth a threshold temperature of 5 C is most valid, while for tender heat loving plants, such as tomatoes and beans, a base temperature of 10 C is more appropriate.

To compute degree-days for a particular day, calculate the average of the maximum and minimum temperature for the day. Then subtract the base temperature from the average temperature.

Example: Maximum Temperature = 24 C
Minimum Temperature = 16 C
Average Temperature = 24 + 16 = 40 / 2 = 20 C

Degree-days above 5 C = 20 - 5 = 15
Degree-days above 10 C = 20 - 10 = 10

If the daily average temperature is below the base temperature, the degree-day value is zero. Negative values are not used because the crop is not set back. When using degree-days be sure to know what base temperature, and also what temperature scale has been used.

Degree-day normals are prepared by adding together the degree-days for each day of the month, for each of 30 years. Then the average monthly degree-day total is calculated. Degree-day information is used to indicate how much heat is available in an area for crop production. By selecting crops or varieties with a heat requirement matched to the location, a successful harvest is more likely.

Corn heat units are widely used for corn hybrid maturity rating. They differ from degree-days described above in that the maximum and minimum temperature are used separately to assess the contribution to corn development. Higher maximum temperatures are preferred and are given more weight than cooler minimums, this reflects the heat loving nature of the crop. A corn heat unit map is presented for the maritime provinces, but not for Newfoundland where there is insufficient heat for even the earliest silage corn hybrids to reach maturity. "Heat units for Corn in the Maritime Provinces" (Pub. No. ACA 79-1) is a publication from which Map 16 is reproduced, that provides more detailed information and is available at local agricultural offices.

iv. Growing Season

Growing season information is important for perennial forage production. The start of the growing season is defined as the date in the spring when the average temperature reaches 5 C. The end of the growing season is defined as the date in the fall when the average temperature reaches 5 C. The value of 5 C is used because at that average temperature, the daily maximum is about 10 C and the minimum is about 0 C. Most plants do not grow when minimum temperatures are below 0 C.

v. Frost

Temperature is measured at weather stations by thermometers located within a louvred screen at a height of 1.2 m above the ground. At a few locations the minimum temperature is also measured at a height of three to four cm above a short grass cover. This is known as the grass minimum temperature. Under conditions when late spring and early fall frosts usually occur - clear skies, cool temperature and light winds - the grass minimum temperature is always lower than the minimum temperature in the screen. The difference varies but is usually 2 to 5 C.

The difference in temperature between screen height and the crop surface must be kept in mind when using climatic frost data. The frost data used in Maps 9, 10, and 11 are for a screen temperature of 0 C. This means that ground temperatures could be colder. The important point is the relative comparisons between areas that the data offers. For within any area, the frost dates may vary as much as several weeks because of differences in local conditions.

Topography has a marked effect on the incidence of frost. After sunset the ground cools rapidly and its temperature soon falls below that of air in contact with it. The surface layer of air becomes cooler and heavier. Over sloping ground this cooled surface air tends to drain to lower levels and to collect in depressions or hollows. In a frost hollow, drainage of cold air into the depression results in frosts much later in the spring and earlier in the autumn than at surrounding locations. Hillside locations will, on the average, tend to have longer frost-free periods than neighbouring stations on lower ground or in a valley.

Night winds have a great influence on temperature differences between hillsides and valleys on clear nights. The best conditions for cold air drainage are found when there is no general air movement. Even a light wind will serve to mix the relatively warm air above with the thin layer of surface air which has cooled through contact with the ground. Moderate winds will prevent differences in temperature between hillsides and valleys.

Bodies of water exert a modifying influence on the climate of surrounding localities and extend the frost-free period. In valleys near the ocean early morning fogs may drift in from the ocean and prevent frost by keeping the ground from cooling. Rivers often yield large amounts of moisture to the air. If the temperature falls to the dew point at night, fog forms in the low-lying land of the valley, thus preventing the temperature from falling any further. On nights with ground fog the hillsides are almost always colder than the valley's floor which is enveloped in fog.

vi. Potential Evapotranspiration

Evapotranspiration is a combination of evaporation and transpiration. Evaporation is the process of water changing from a liquid to a gas. Transpiration is a special case of evaporation when the water passes through the stomates, or pores, of living plants. A plant can transpire more water than can be evaporated from the soil surface it covers.

Potential evapotranspiration is a calculated value representing how much water would be removed by the atmosphere from a well watered surface completely covered by a short grass crop. The calculation of this value takes into account temperature, humidity, wind and sun. It represents the maximum amount of water the atmosphere can remove under ideal conditions, which are seldom realized. It is essentially an indication of crop water requirement. Comparing evapotranspiration to growing season rainfall gives an indication of whether a place is likely to be droughty. Evapotranspiration is that part of the hydrologic cycle which returns to the atmosphere the precipitation

which does not runoff or percolate deep into the soil. The actual evapotranspiration of a crop must not exceed the seasonal rainfall or the crop yield will be reduced.

Actual evapotranspiration is very difficult to measure, but is usually considerably less than the potential evapotranspiration. Table 1 presents the average seasonal values for 20 stations in Atlantic Canada.

Table 1. Average Potential Evapotranspiration (mm)
May to September Inclusive, 1941-1970

NEW BRUNSWICK		NEWFOUNDLAND	
Bathurst	518.0	Buchans 'A'	446.7
Edmundston	585.9	Burgeo	233.5
Fredericton CDA	589.2	Daniels Harbour	262.6
Moncton 'A'	527.1	Gander 'A'	416.6
Saint Andrews	483.6	St. John's 'A'	339.5
Woodstock	607.1	Stephenville 'A'	322.7
NOVA SCOTIA		**PRINCE EDWARD ISLAND**	
Debert 'A'	608.0	Charlottetown CDA	447.5
Greenwood 'A'	587.0	Summerside 'A'	450.0
Kentville CDA	560.0		
Nappan CDA	529.7		
Sydney 'A'	462.4		
Yarmouth 'A'	399.7		

This data is from the Handbook on Agricultural and Forest Meteorology, edited by R. A. Treidl, Canadian Climate Centre, Atmospheric Environment Service, 1978.

vii. Sunshine Hours

The number of hours of bright sunshine is recorded by a Campbell-Stokes recorder. It is a spherical glass lens which focuses the sun's rays onto a piece of paper marked with the hours of the day. The bright sun's rays will burn or scorch the paper. If it is cloudy, foggy, or hazy, they will not.

Bright sunshine is recorded at 45 stations in Atlantic Canada, which are too few to map this parameter. Instead, normal values for 18 stations in agricultural areas are presented in Table 2.

TABLE 2. AVERAGE HOURS OF BRIGHT SUNSHINE, 1951-1980.

NEW BRUNSWICK	MAY	JUNE	JULY	AUG	SEP	TOTAL
Campbellton	223.5	226.7	234.9	230.1	168.3	1083.5
Chatham 'A'	209.5	228.8	253.1	237.6	178.9	1107.9
Fredericton 'A'	200.3	205.9	232.9	221.2	167.3	1027.6
Moncton 'A'	207.8	225.8	243.2	230.2	165.8	1072.8
Saint John 'A'	203.4	203.0	218.5	212.5	166.0	1003.4
NOVA SCOTIA						
Kentville CDA	201.5	217.0	239.3	224.9	174.8	1057.5
Nappan CDA	193.6	209.3	231.8	212.8	162.5	1010.0
Sydney 'A'	199.0	225.7	243.4	225.6	167.4	1061.1
Truro	196.1	218.1	224.4	212.1	154.5	1005.3
Yarmouth 'A'	221.8	211.4	206.9	209.2	176.0	1025.3
PRINCE EDWARD ISLAND						
Charlottetown CDA	196.6	220.8	241.3	218.1	176.0	1052.8
Oleary PEIDA	219.0	231.2	250.7	243.8	171.0	1115.7
Summerside 'A'	205.3	240.7	265.0	240.5	169.4	1120.9
NEWFOUNDLAND						
Burgeo	162.1	171.6	157.5	165.6	149.3	806.1
Daniels Harbour	184.4	189.8	204.2	179.8	130.5	888.7
Gander 'A'	162.3	183.6	214.2	186.3	146.0	892.4
St. John's 'A'	158.9	186.6	220.1	186.0	146.5	898.1
Stephenville 'A'	185.8	189.8	206.6	186.3	133.0	901.5

D. FARM LEVEL CLIMATE

The climate at the farm level can often be different than the climate of the surrounding area. Local features all interact to produce a climate unique to the location. Knowledge of these factors when used with the values indicated in the atlas, should provide a better indication of what to expect on the farm in the future. The factors that influence the climate at the farm level are;

- large water bodies,
- slope,
- aspect,
- wind, and
- elevation.

Large water bodies modify the local climate by warming in winter and cooling in summer. This effect is most pronounced near the coast but may extend inland several kilometers depending upon the elevation and topography of the land. For example, the eastern coast of New Brunswick is relatively flat and the seabreeze extends many kilometers inland, whereas the Bay of Fundy coast of New Brunswick and the southern coast of Newfoundland have steep topography which limits the flow of moderating marine air to very near the coast. When the prevailing wind direction comes from the ocean the moderating influence may be greater. If the prevailing winds blow out to sea from the land, then the marine modifications may be reduced. Proximity to large lakes can produce a similar effect.

Slope plays a major role in farm level climate. Valley bottoms experience colder nighttime temperatures and usually warmer daytime maximums than either midslopes or hilltops. However, the total heat units over an entire growing season, are usually higher on midslopes followed by hilltops and lastly, valley bottoms. This order is much more pronounced when heat units are accumulated between frost dates. Cold air running down the slopes and pooling in valley bottoms causes later spring and earlier fall frost dates. Hilltops usually have a shorter frost-free period than midslopes because of greater exposure to radiative loss to the atmosphere at night. Exposed hilltops have slightly cooler maximum temperatures than midslopes. In winter, midslopes accumulate more snow than hilltops, particularly on the lee side of the prevailing winds. The influence of aspect can change these relationships.

Aspect, or orientation to the direction of the sun, has two roles in crop production. In winter, south facing slopes produce warmer conditions that may result in harmful freezing and thawing cycles. Snow melt accounts for less depth and denser snow packs on south slopes. This results in a decrease in the protective value of the snow which may be important to overwintering perennial crops. In contrast, the growing season conditions are more favourable on south slopes. Warm south and west facing slopes provide more heat units and higher soil temperatures early in the season. In Atlantic Canada, spring soil moisture conditions are generally on the wet side, depending upon soil type. In this instance, south slopes have higher evaporative losses and the field trafficability is earlier as a result.

Exposure to high winds is usually detrimental to crop production, and many studies indicate better yields in protected or sheltered areas. Two suggested reasons for this are dessication of plants from high evapotranspiration losses and physical damage to plants directly from the wind. The establishment of some barrier to the wind on the

prevailing wind side, may be required to improve the situation. If additional winter snow cover is desirable, wind breaks will increase this cover. In Atlantic Canada, summer winds are usually from the south and southwest while winter winds are from the north and northeast.

Elevation has the most influence on precipitation totals and heat unit accumulation. Generally, higher elevations have lower heat units. Precipitation on the other hand, increases with elevation due to orographic lifting. When warm moist air masses are forced upwards by rising land the air mass cools and the moisture is precipitated out as rain or snow. The proportion of precipitation that falls as snow also increases with higher elevation.

E. DISCUSSION OF MAPS

MAP 1
MAP 1A The name and location are shown for the 233 stations in Atlantic Canada, with climatic data available for the period 1951-1980, used to prepare the following maps.

MAP 2 Annual total precipitation includes both snow and rain. Snow was converted to the water equivalent using 1 cm of snow equals 1 mm of water. Precipitation is greatest along the Atlantic Coast of Nova Scotia, the Fundy Coast of New Brunswick and over most of Cape Breton. This is due to moist air being blown onshore by southerly and easterly winds which accompany storms passing over the region. When moist air encounters rising land, it cools as it is forced upwards, causing water to condense and fall as rain or snow. In lower lying areas, such as central Nova Scotia, the Annapolis Valley and the Northumberland Coastal lowlands of New Brunswick and Nova Scotia, precipitation amounts are less. This is caused by the air descending and warming, thus being able to hold more water and producing less precipitation. In effect, the topography shelters these areas from storm winds. Air masses moving into north eastern coastal New Brunswick have lost much of their moisture over the central highlands resulting in lower precipitation in these areas.

MAP 2A The greatest precipitation amounts are along the south coast of Newfoundland. Precipitation decreases with distance inland to the north. The lowest precipitation amounts are found along the eastern coast of the Northern Peninsula and in the central part of northern Newfoundland.

MAP 3 The distribution of rainfall is shown for a period roughly corresponding to the growing season. It is important for agricultural crops to have sufficient rain, evenly distributed over the growing season, to meet crop water requirements. Seasonal precipitation, at Sydney and Yarmouth, exceeds potential evapotranspiration (Table 1) so they are unlikely to have crop water deficits. Parts of the eastern shore of New Brunswick and an area around Woodstock experience small deficits in July and August on a regular basis while parts of the Annapolis Valley and the North Shore, depending on soil type, may have crop water deficits in years with below normal rainfall.

MAP 3A The summer rainfall pattern shows the same trends as total precipitation. Maximum rainfall occurs along the south coast and falls off rapidly inland. The lowest rainfall amounts are found along the north and east coast. The Long Range Mountains receive fairly high rainfall.

MAP 4 The largest heat unit totals in the Maritimes are found in the Annapolis Valley of Nova Scotia, the Grand Lake area of New Brunswick, and the coastal area along the Northumberland Strait. Cold Atlantic waters reduce degree-day totals along athe south and eastern shore of Nova Scotia and along the Bay of Fundy. This influence decreases with distance inland. The warm waters of the Northumberland Strait keep the adjacent Coastal areas warm.

MAP 4A The northeast part of Newfoundland, including the northern part of the Avalon peninsula, has the most heat units in the province. This area is sheltered from the prevailing south-westerly winds. A narrow coastal strip from Corner Brook to Stephenville also has high heat unit totals, in this case due to the influence of the warm waters of the Gulf of St. Lawrence. The high elevations of the Long Range Mountains have the lowest heat unit totals. Most coastal areas have low heat units.

MAP 5 The same trends and influences produce much the same pattern of degree-days above 10 C as in MAP 4. The totals are much lower because of the higher base temperature.

MAP 5A The same trends and influences produce much the same pattern in degree-days above 10 C as is seen in Map 4A. The totals are much lower because of the higher base temperature. The southwest coast is as cool as the higher elevations of the Long Range Mountains.

MAP 6 The growing season starts first in western Nova Scotia and the lower Saint John river valley because of the relatively warm waters of the Bay of Fundy and Lurcher at this time of year. The warming trend then continues eastward. The last areas to warm up are along the eastern shore and the south-east shore of Cape Breton. In New Brunswick and Prince Edward Island northern latitude and higher elevation account for delaying the start of the growing season.

MAP 6A The areas which warm up earliest in the spring are the same as those with the highest degree-days above 10 C. The south-east part of the Avalon peninsula is later because of the effect of the cold Labrador Current. The Long Range Mountains are the last to warm up.

MAP 7 The most northerly areas tend to cool first and coastal areas experience long autumns due to the modifying effect of the water. The upland areas of the maritimes are the first to cool in the fall. Most agricultural areas end the growing season about the same time. The Atlantic Coast and western Nova Scotia are the last to end the growing season.

MAP 7A The Long Range Mountains are the first to cool in the fall. Interior regions are the next and coastal areas stay warm the longest. The southeast part of Newfoundland is the last area to cool to 5C.

MAP 8 The longest growing season is found in the southern half of the Maritimes, particularly near the coast. The remaining agricultural areas have a growing season about a week or two shorter.

MAP 8A The longest growing season is found in the northern Avalon peninsula. Southeast Newfoundland and the west coast have the next longest growing season. The Northern peninsula has the shortest.

MAP 9 A narrow strip along the coast from Digby neck to Cape Sable is generally frost-free after April 30. The Coastal areas of the South Shore around the Annapolis Basin, along with an area at the eastern end of the Valley near the Minas Basin are generally frost-free after May 15. A narrow strip along the shores of the Northumberland Strait and most of the agricultural areas of the three provinces are frost-free after May 30, with high elevations recording frost about two weeks later. It is important to remember that in half the years the last spring frost will occur after the average dates on the map.

MAP 9A A narrow strip along the south, west, and east coasts of Newfoundland is on the average frost-free by the end of May. Interior parts of the province and the Northern peninsula are still susceptible to frost after June 14.

MAP 10 Most coastal areas except the eastern coast of New Brunswick and the northern coast of Prince Edward Island are frost-free until mid-October. Fall frosts occur earlier further inland, with the earliest frosts occurring in upland or interior areas before September 1. These dates are only indications of differences between areas, since local conditions can make a big difference. There is a 50% chance that the first fall frost will occur earlier than the date indicated.

MAP 10A The south and east coasts remain frost-free latest in the fall. Interior areas and the Northern Peninsula experience the earliest fall frosts. The remaining inland and coastal areas are intermediate.

MAP 11 The longest frost-free periods are along the southwest coasts of New Brunswick, Nova Scotia and Prince Edward Island. The frost-free period decreases rapidly with distance away from the moderating influence of the ocean. The coastal area along the Northumberland Strait has a frost-free period of about 130 days very near the water. Inland areas and the higher elevations have the shortest frost-free periods.

MAP 11A The longest frost-free period is along the south coast from Burgeo to Cape Ray. The next shortest frost-free period is along the south, west and east coasts. Inland areas and the eastern part of the Northern Peninsula have the next shortest frost-free period. The interior of the province has a frost-free period of only 70 days.

MAP 12 The coldest average January temperatures are found in the Central Highlands of New Brunswick, becoming progressively warmer to the south and toward the Bay of Fundy. Coastal areas along the frozen Northumberland Strait are the coldest, while those around Cape Sable are the warmest.

MAP 12A The average January temperature is lowest in the Northern peninsula and highest in south eastern Newfoundland. The interior of the province is coolest, gradually warming toward the coast.

MAP 13 The coldest areas are the central Highlands of New Brunswick and Nova Scotia, and the central part of Prince Edward Island. The frozen Northumberland Strait and Gulf of St. Lawrence have little moderating influence on the adjacent coastal areas. The distribution of the colder areas indicates the influence of unmoderated cold north or west winds.

The period of record is very important when comparing extreme values. The longer the record the more representative is the extreme. As with frost, site characteristics of shelter and topography play a role in determining how cold it gets on a calm, clear night. Considerable differences in extreme minimum temperature can occur between nearby areas with different features. The presence of snow cover is very important to perennial agricultural crops in most areas of the Maritimes.

MAP 13A The extreme minimum temperature shows much the same pattern as in Map 12.

MAP 14 The warmest average July temperatures occur in the eastern Annapolis Valley, the Saint John River Valley from Woodstock to Grand Lake, around Summerside and Charlottetown, Prince Edward Island, and the Northumberland Coastal lowlands. These areas are sheltered from prevailing westerly winds. The coolest area is Cape Sable, Nova Scotia. The cooling influence of the Atlantic and the Bay of Fundy is quite pronounced and can extend inland up to 20 kilometers.

MAP 14A The warmest average July temperatures occur in the interior of the province. Coastal areas are the coolest, but the north and south eastern coasts are cooler than the east and west coasts.

MAP 15 The highest extreme July maximum temperatures occur in upland and interior regions. Agricultural areas do not experience temperatures hot enough to cause problems to plant growth.

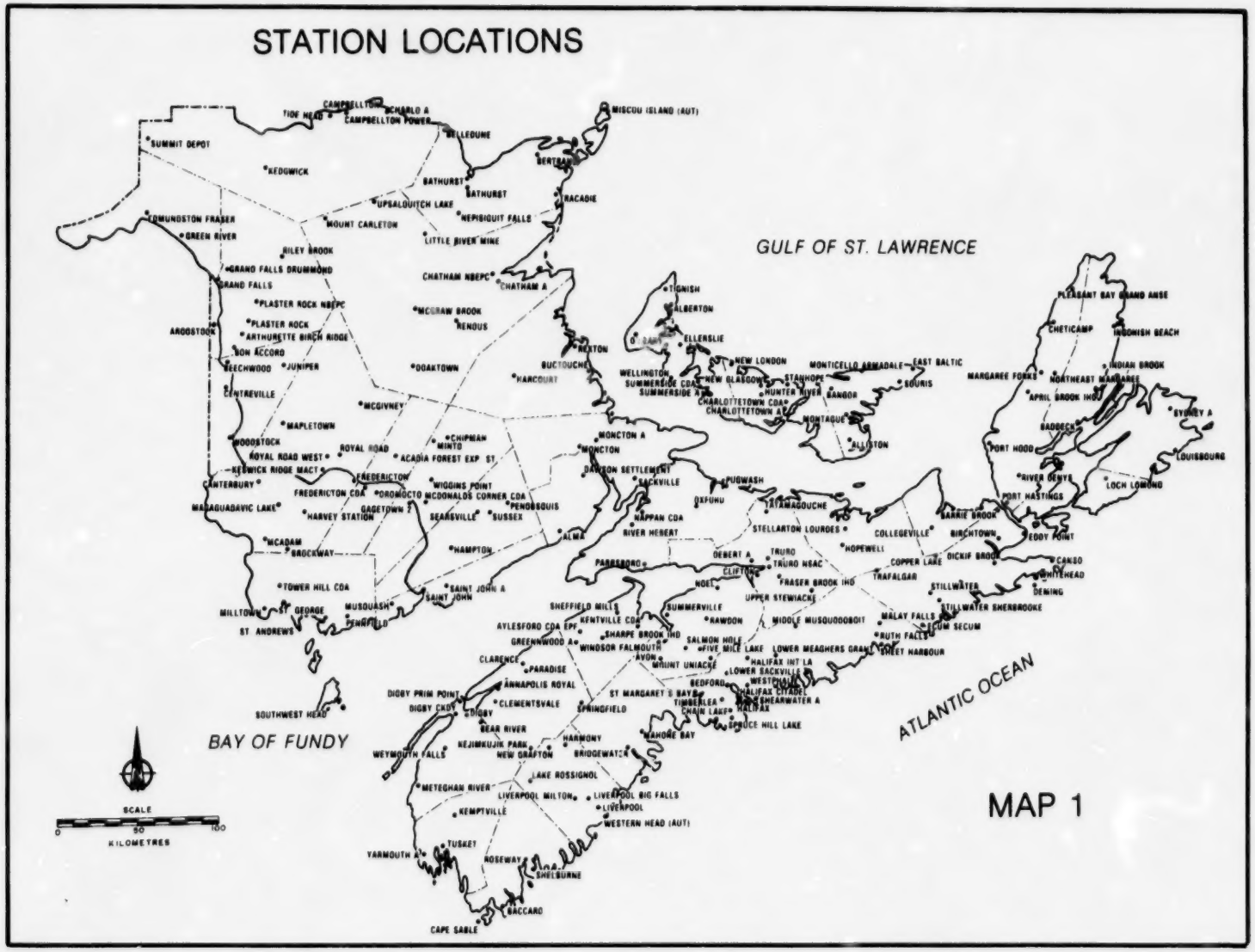
MAP 15A The west and south coasts are cooler, due to the influence of the prevailing winds, than the remainder of the province. The influence of the cool Labrador current is evident in the southeast.

MAP 16 Corn heat units are distributed much the same as growing degree-days are from May to September (Map 5). These heat units are accumulated between planting date and average date of first fall frost. The planting date chosen for this map corresponds to the time when the average daily temperature is approximately 11 C. The highest heat unit totals, which make available the largest selection of hybrids that can reach maturity, are found in the Kentville, Charlottetown, and Fredericton areas. The corn hybrids that mature later require more corn heat units.

MAP 16A There is no corn heat unit map for Newfoundland since there is insufficient heat for even the earliest available hybrids to reach maturity.

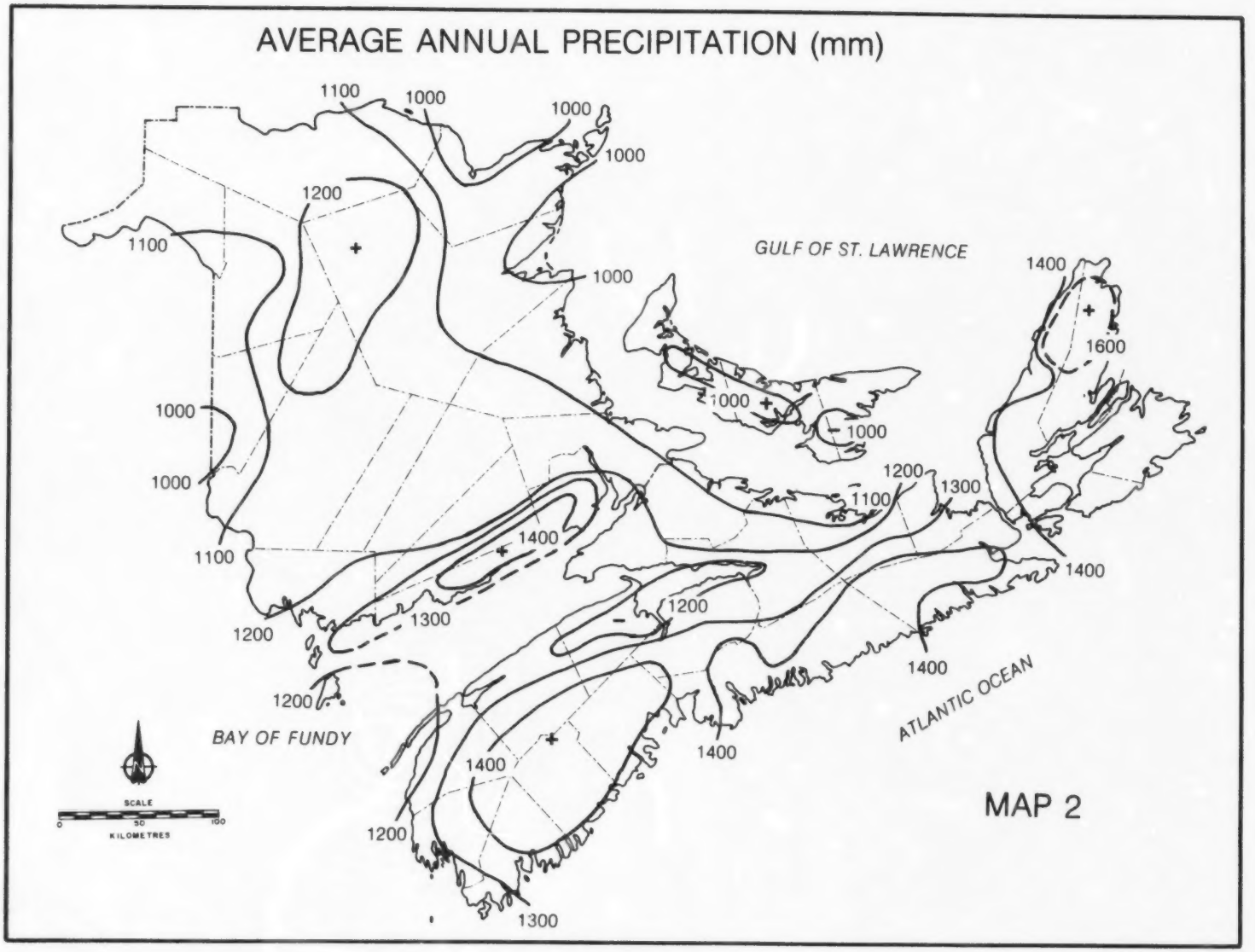
MAP 17
MAP 17A The climatic zones in these two maps are defined by combinations of arbitrarily selected categories of:
- annual total degree-days above 5 C (Maps 3, 3A) and
- May to September total precipitation (Maps 2, 2A).

The purpose of these zones is to quickly provide information about heat units and growing season precipitation found in various parts of the region. Generally areas with the highest heat units and moderate precipitation are the most favourable for agriculture. The various classes are intended to provide a convenient and easy way of comparing the results of variety trials conducted in various parts of the region. They may also serve as a guide to locating variety trials and locations with different climatic characteristics. However, many possible combinations of climatic criteria may be used to produce climatic zones, which may be tailored to suit particular needs.

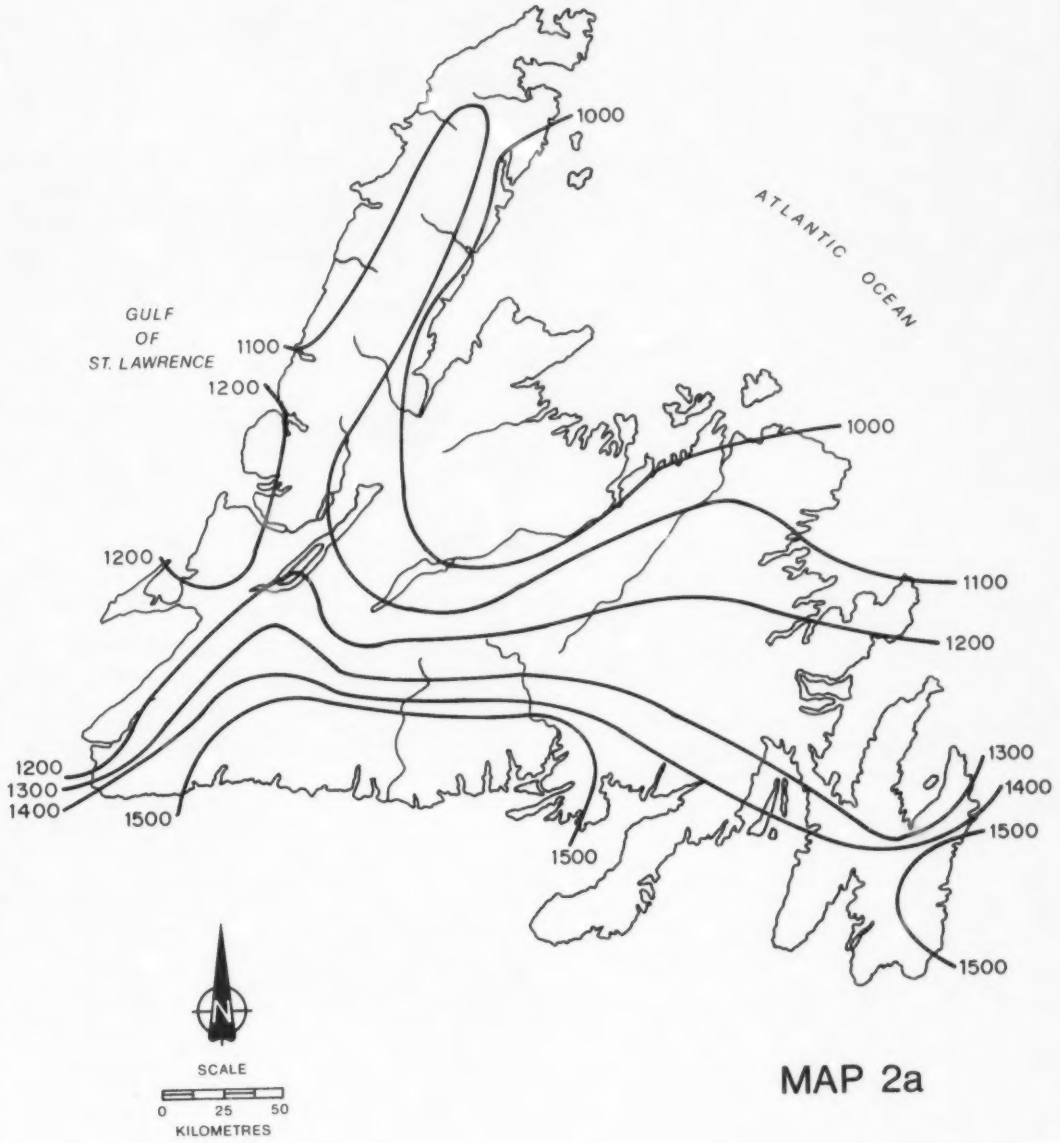

STATION LOCATIONS
GULF OF ST. LAWRENCE
ATLANTIC OCEAN
BAY OF FUNDY
MAP 1
SCALE
0 50 100
KILOMETRES
CAMPBELLTON
CHARLO A
CAMPBELLTON POWER
TIDE HEAD
MISCOU ISLAND (AUT)
BELLEDUNE
BERTRAND
SUMMIT DEPOT
KEDGWICK
BATHURST
BATHURST
RACADIE
EDMUNDSTON FRASER
GREEN RIVER
UPSALQUITCH LAKE
NEPISIGUIT FALLS
MOUNT CARLETON
LITTLE RIVER MINE
RILEY BROOK
GRAND FALLS DRUMMOND
GRAND FALLS
CHATHAM NBEPC
CHATHAM A
PLASTER ROCK NBEPC
PLASTER ROCK
ARTHURETTE BIRCH RIDGE
ARCOSTOOK
MCGRAW BROOK
NENOUS
RICHIBUCTO
BUCTOUCHE
HARCOURT
ON ACCORD
BEECHWOOD
JUNIPER
OAKTOWN
CENTREVILLE
MCGIVNEY
MAPLETOWN
WOODSTOCK
ROYAL ROAD
ROYAL ROAD WEST
ACADIA FOREST EXP ST
CHIPMAN
MINTO
MONCTON A
MONCTON
KEWICK RIDGE MACT
CANTERBURY
FREDERICTON
WIGGINS POINT
FREDERICTON CDA
DROMOCTO
MCDONALDS CORNER CDA
PENOBSQUIS
DAWSON SETTLEMENT
SACKVILLE
PUGWASH
MAGAGUADAVIC LAKE
HARVEY STATION
GAGETOWN
SEARSVILLE
SUSSEX
OXFUNU
AMAGOUCHE
NAPPAN CDA
RIVER HEBERT
STELLARTON LOURDES
COLLEGEVILLE
BARRIE BROOK
BIRCHTOWN
EDDY POINT
MCADAM
BROCKWAY
HAMPTON
ALMA
DEBERT A
TRURO
HOPEWELL
PARRSBORO
TRURO NSAC
COPPER LAKE
DICKIE BROOK
CANSO
CLIFTON
TRAFALGAR
WHITEHEAD
TOWER HILL CDA
SAINT JOHN A
SAINT JOHN
NOEL
STILLWATER
DENING
UPPER STEWIACKE
MILLTOWN
ST GEORGE
MUSQUASH
ST ANDREWS
SHEFFIELD MILLS
SUMMERVILLE
STILLWATER SHERBROOKE
AYLESFORD CDA EPC
KENTVILLE CDA
RAWDON
MIDDLE MUSQUODOBOIT
MALAY FALLS
SCUM SECUM
GREENWOOD A
WINDSOR FALMOUTH
SHARPE BROOK IND
SALMON HOLE
FIVE MILE LAKE
LOWER MEAGHERS GRANT
RUTH FALLS
SWEET HARBOUR
CLARENCE
PARADISE
AVON
MOUNT UNIACKE
HALIFAX INT LA
LOWER SACKVILLE
ANNAPOLIS ROYAL
BEDFORD
WESTPHAL
DIGBY PRIM POINT
ST MARGARET S BAY
HALIFAX CITADEL
SHEARWATER A
CLEMENTSVALE
SPRINGFIELD
TIMBERLEA
CHAIN LAKE
HALIFAX
SOUTHWEST HEAD
DIGBY CDA
DIGBY
BRUCE HILL LAKE
BEAR RIVER
MAHONE BAY
KEJIMKUJIK PARK
HARMONY
WEYMOUTH FALLS
NEW GRAFTON
BRIDGEWATER
LAKE ROSSIGNOL
METEGHAN RIVER
LIVERPOOL MILTON
LIVERPOOL BIG FALLS
LIVERPOOL
KEMPTVILLE
WESTERN HEAD (AUT)
TUSKET
YARMOUTH A
ROSEWAY
SHELBURNE
BACCARO
CAPE SABLE
TIGNISH
ALBERTON
ELLERSLIE
NEW LONDON
MONTICELLO ARMADALE
EAST BALTIC
WELLINGTON
SUMMERSIDE CDA
NEW GLASGOW
STANHOPE
SOURIS
SUMMERSIDE A
HUNTER RIVER
BANGOR
CHARLOTTETOWN CDA
CHARLOTTETOWN A
MONTAGUE
ALBERTON
PLEASANT BAY GRAND ANSE
CHETICAMP
INGONISH BEACH
INDIAN BROOK
MARGAREE FORKS
NORTHEAST MARGAREE
APRIL BROOK INDY
SYDNEY A
BADDECK
PORT HOOD
LOUISBOURG
RIVER DENYS
LOCH LOMOND
PORT HASTINGS

STATION LOCATIONS

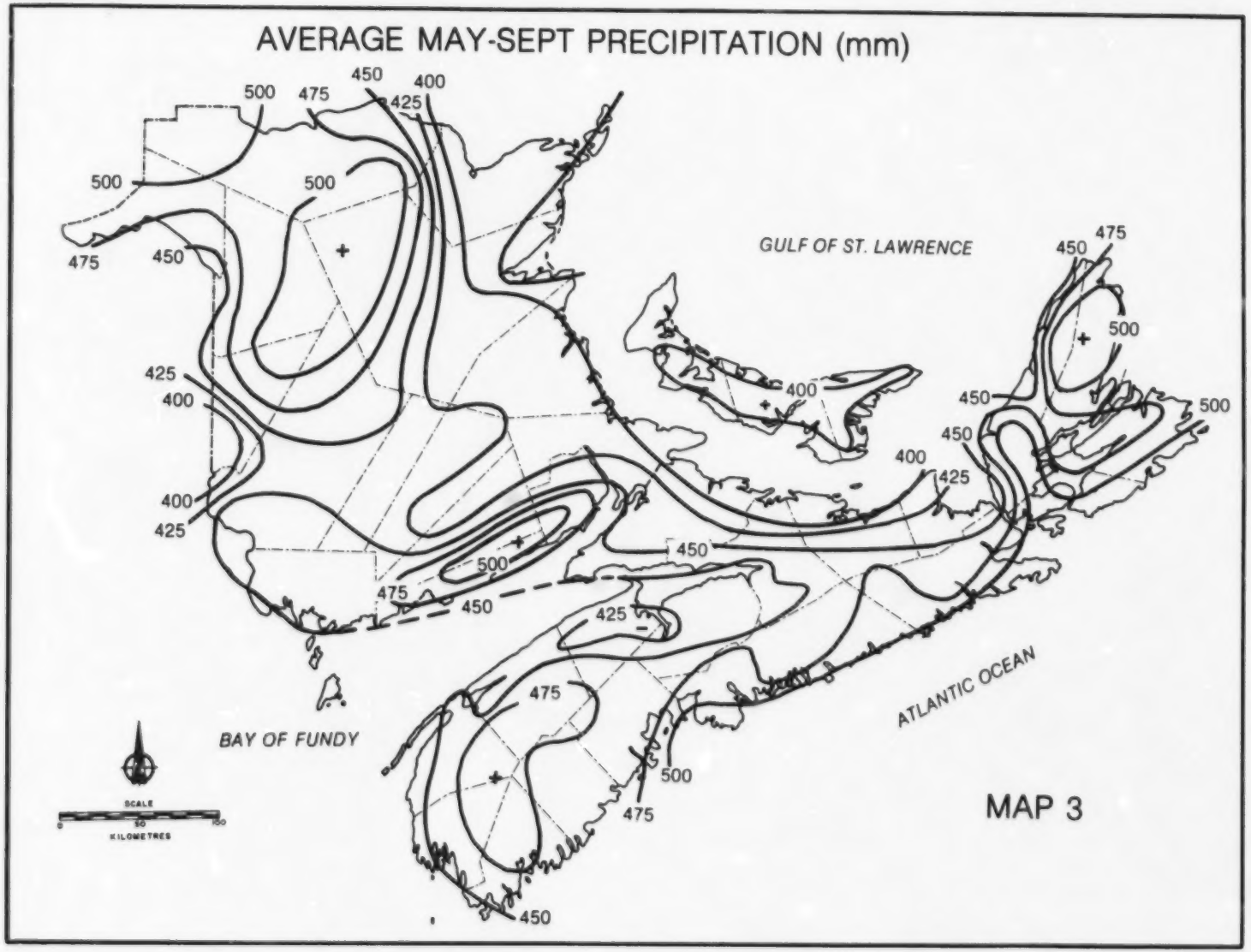
MAP 1a


AVERAGE ANNUAL PRECIPITATION (mm)
1100
1000
1000
1000
1200
1100
1000
1000
GULF OF ST. LAWRENCE
1400
1600
1000
1000
1000
1000
1200
1300
1100
1400
1100
1400
1200
1300
1200
1400
1200
1400
ATLANTIC OCEAN
BAY OF FUNDY
1400
1200
1300
N
SCALE
0
50
100
KILOMETRES
MAP 2

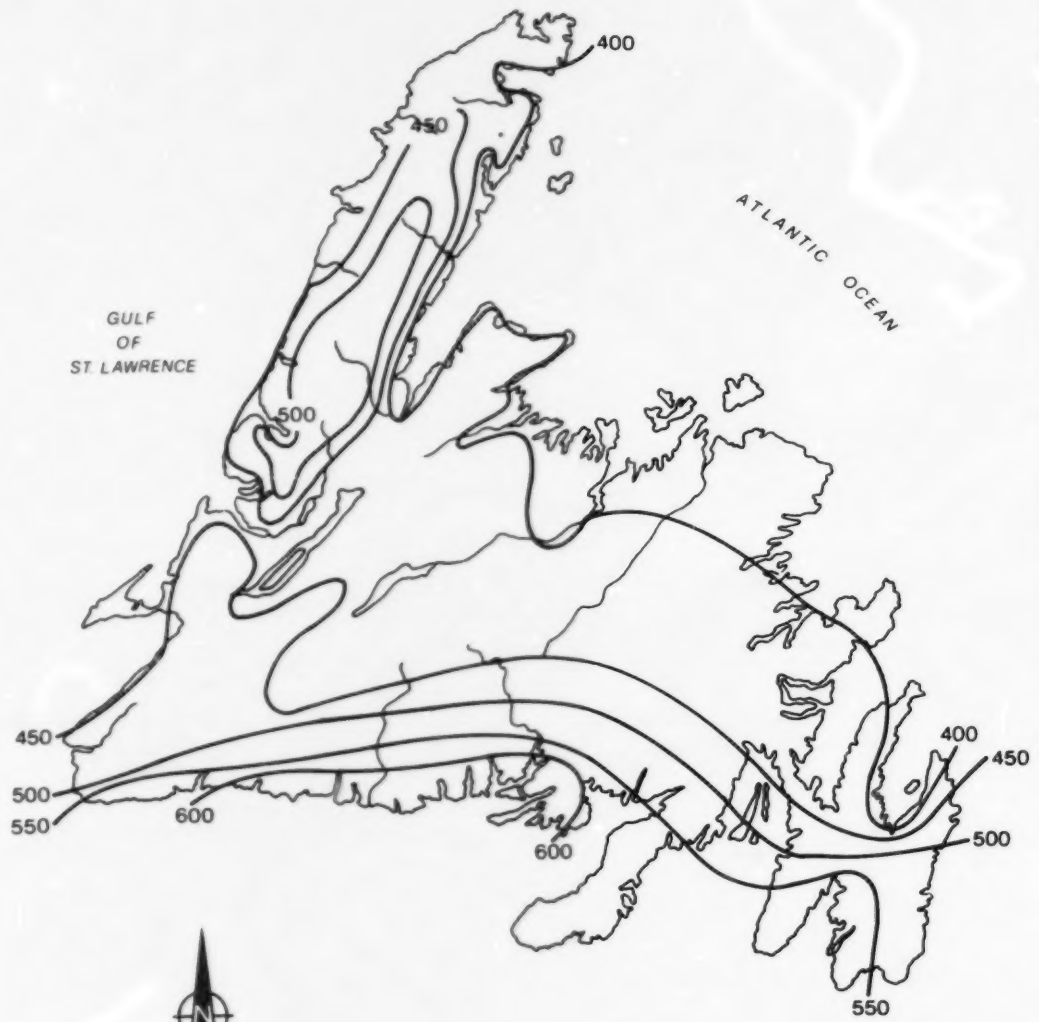
AVERAGE ANNUAL PRECIPITATION (mm)



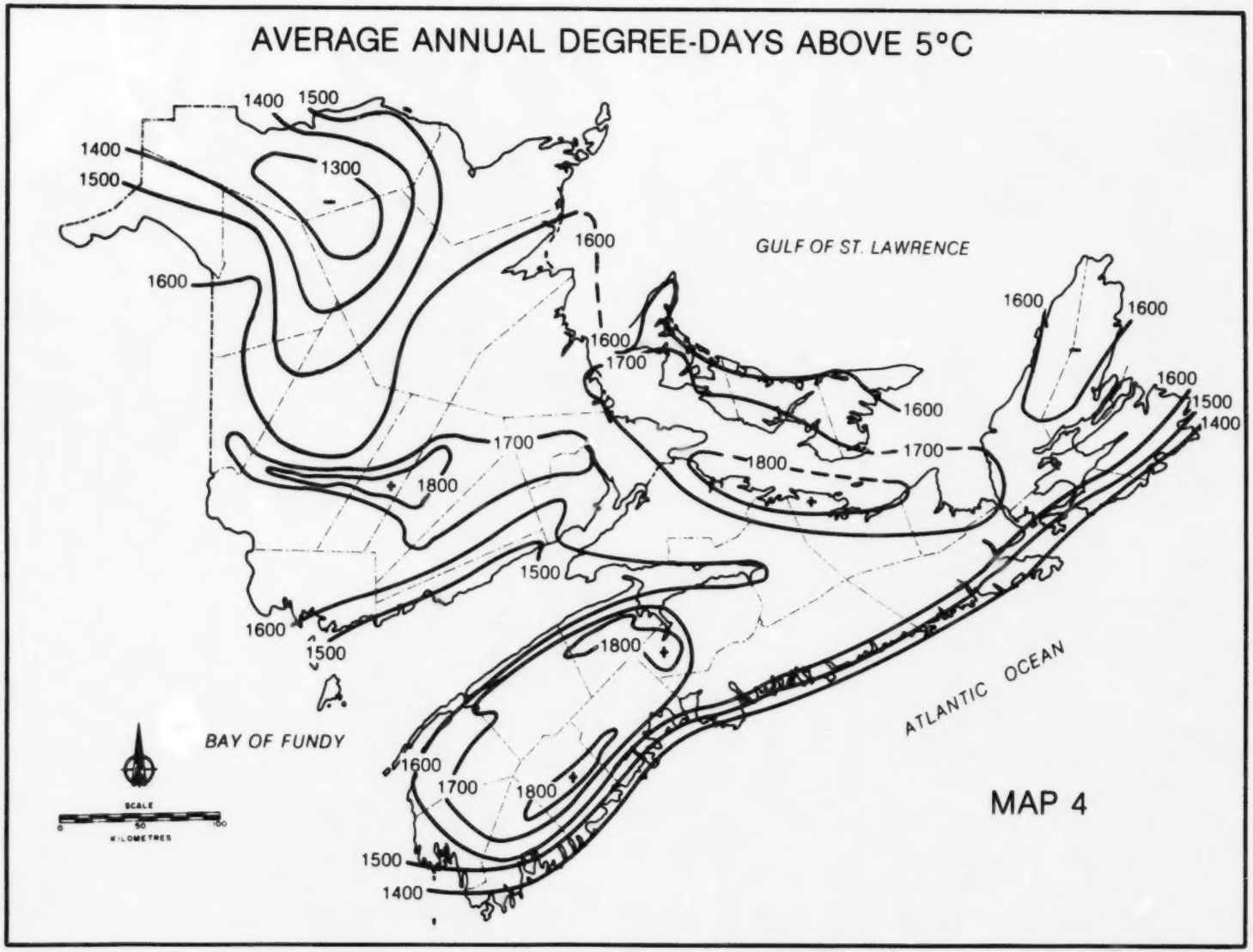
MAP 2a


AVERAGE MAY-SEPT PRECIPITATION (mm)
500
475
450
400
425
GULF OF ST. LAWRENCE
BAY OF FUNDY
ATLANTIC OCEAN
SCALE
0
50
100
KILOMETRES
MAP 3

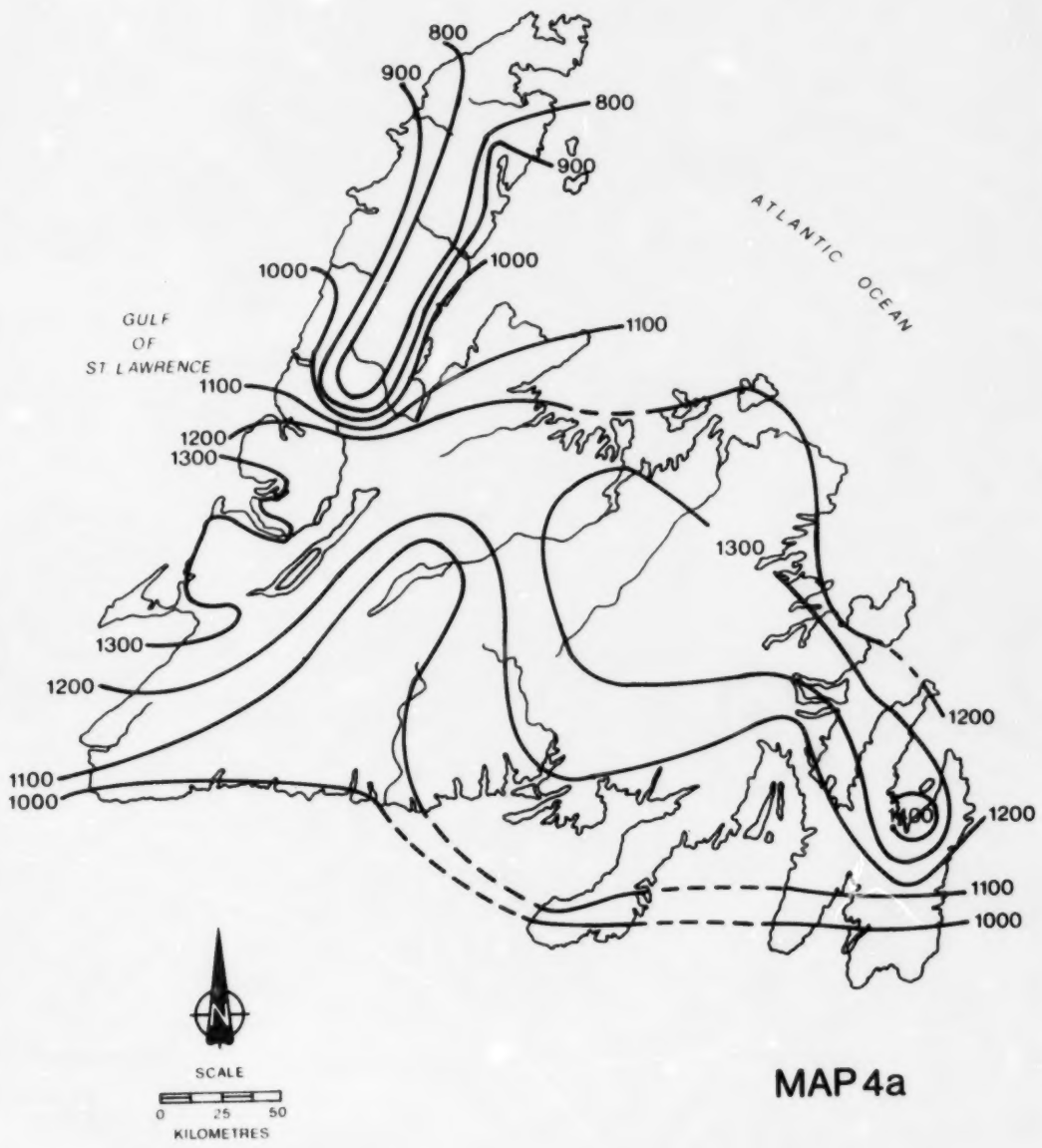
AVERAGE MAY-SEPTEMBER PRECIPITATION (mm)



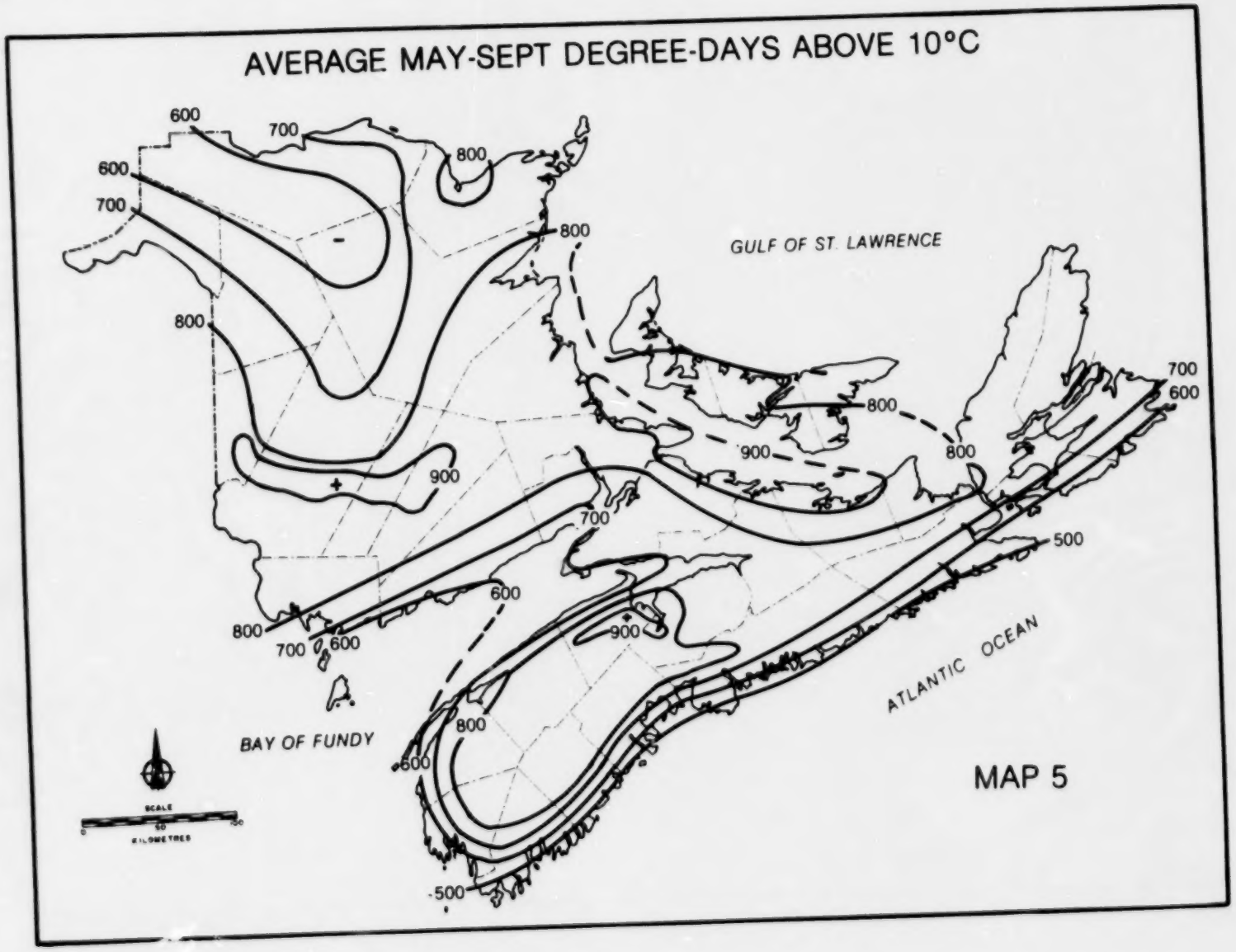
MAP 3a


AVERAGE ANNUAL DEGREE-DAYS ABOVE 5°C
1400
1500
1300
1600
1700
1800
GULF OF ST. LAWRENCE
BAY OF FUNDY
ATLANTIC OCEAN
SCALE
0
50
100
KILOMETRES
MAP 4

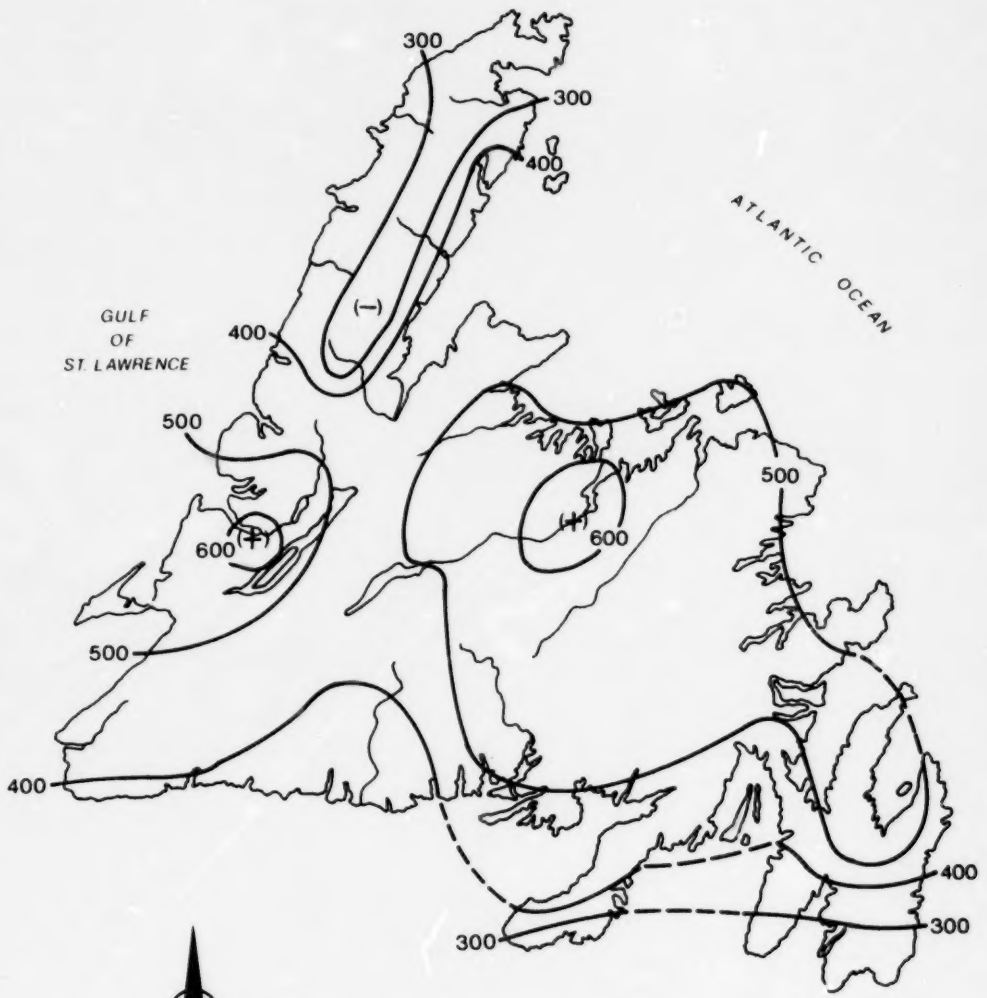
AVERAGE ANNUAL DEGREE-DAYS ABOVE 5°C



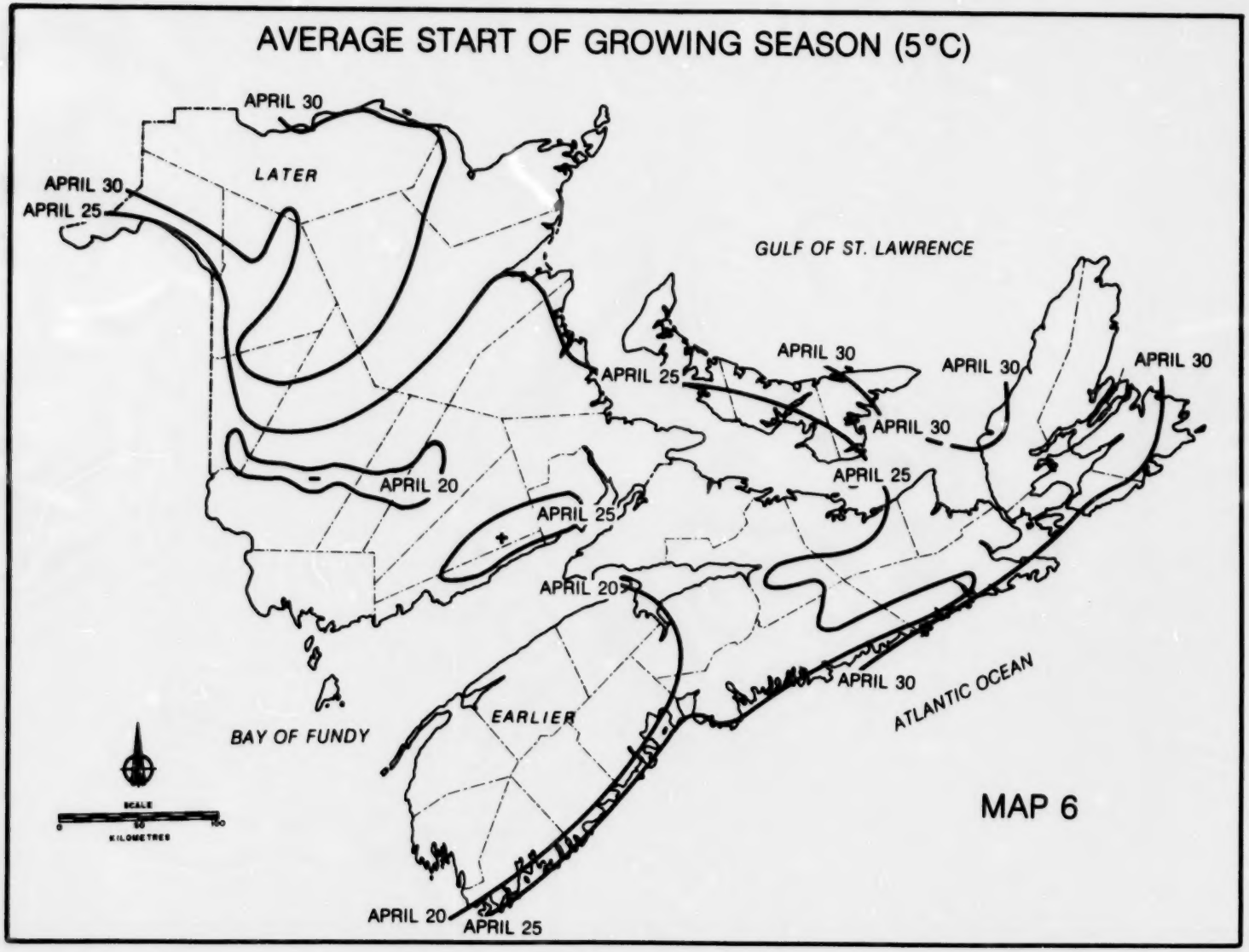
MAP 4a


AVERAGE MAY-SEPT DEGREE-DAYS ABOVE 10°C
600
700
800
600
700
800
800
GULF OF ST. LAWRENCE
700
600
800
900
800
900
700
500
600
800
700
600
900
ATLANTIC OCEAN
BAY OF FUNDY
800
600
500
SCALE
KILOMETRES
MAP 5

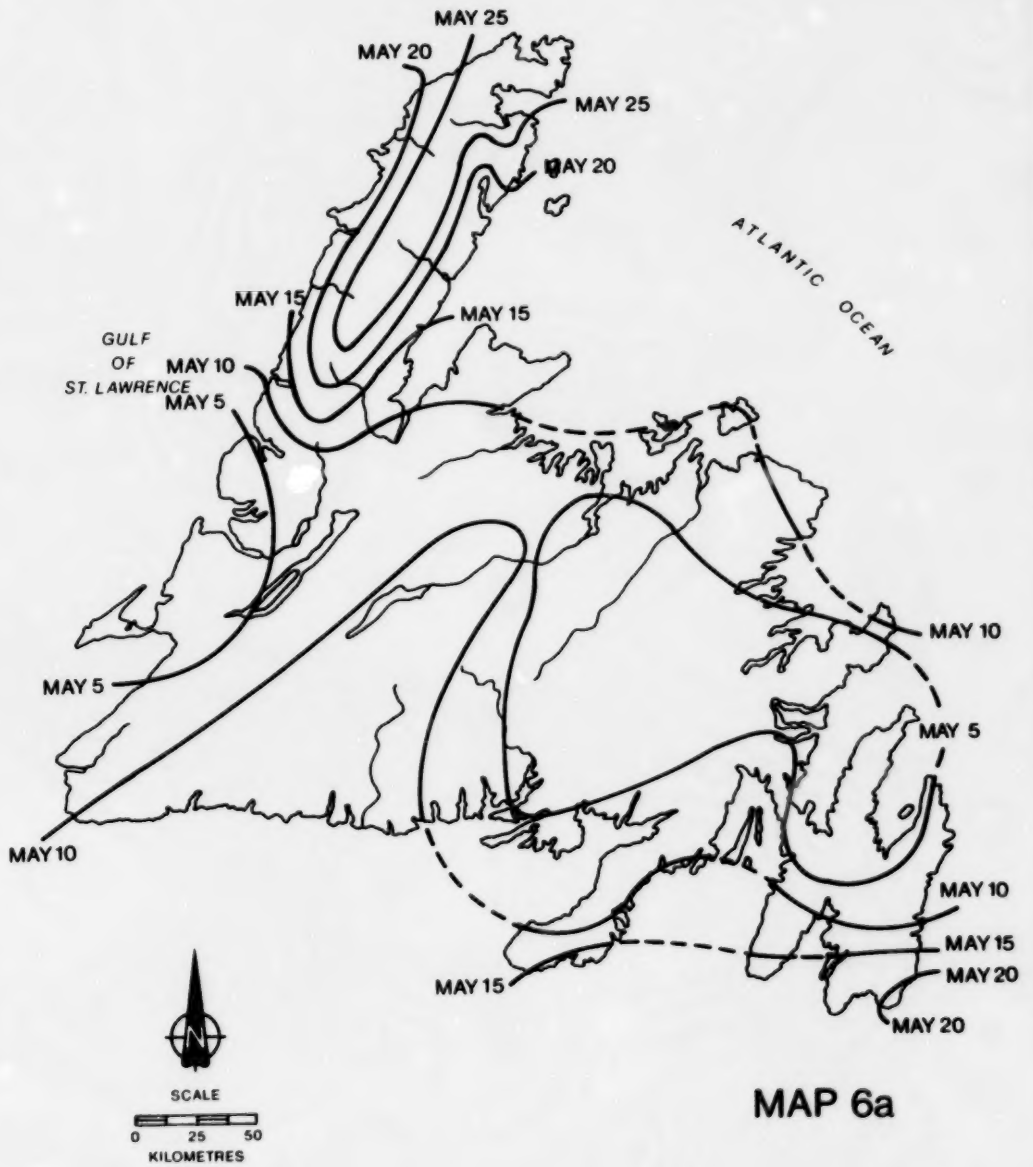
AVERAGE MAY-SEPTEMBER DEGREE DAYS ABOVE 10°C



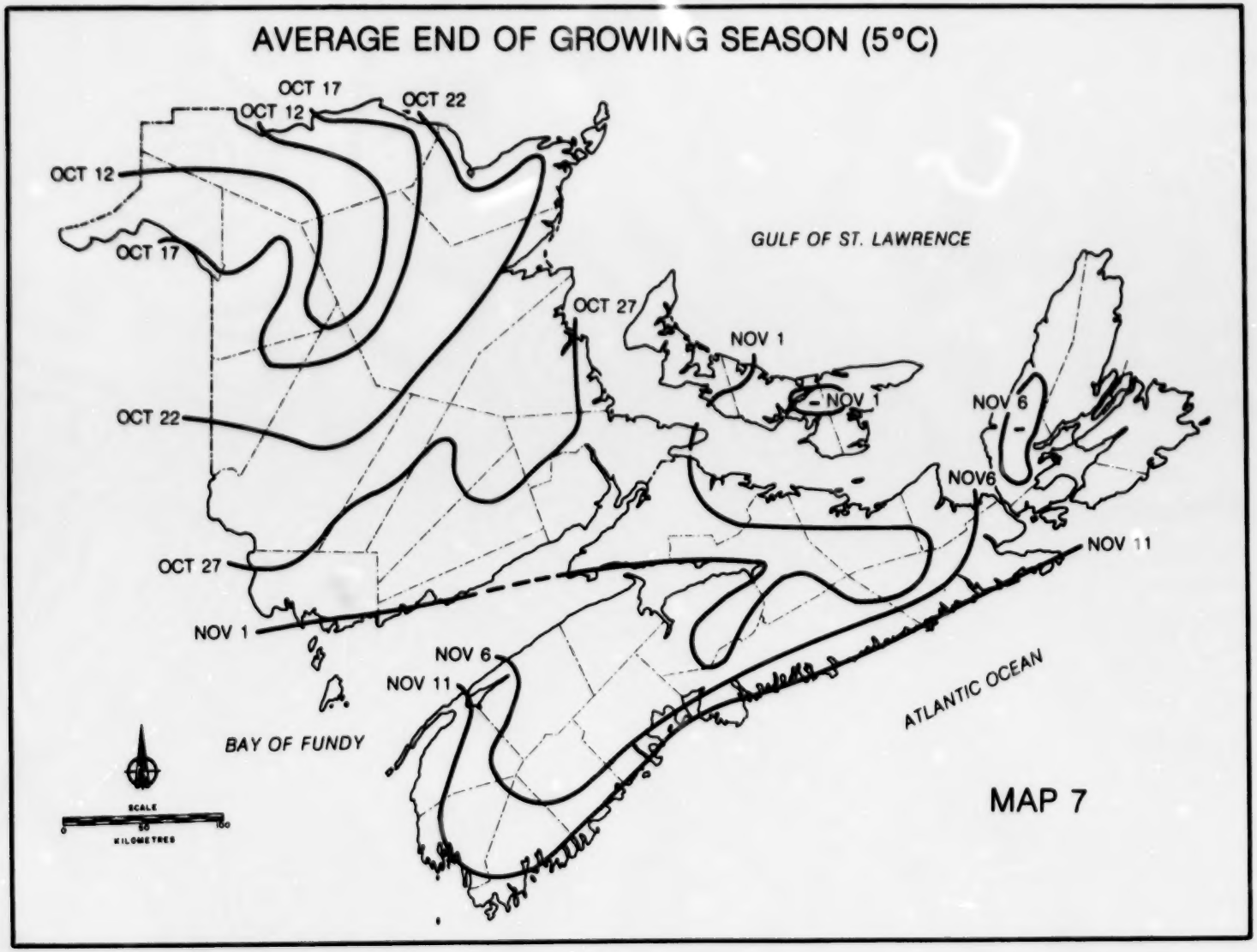
MAP 5a


AVERAGE START OF GROWING SEASON (5°C)
APRIL 30
LATER
APRIL 30
APRIL 25
GULF OF ST. LAWRENCE
APRIL 30
APRIL 30
APRIL 30
APRIL 25
APRIL 30
APRIL 25
APRIL 20
APRIL 25
APRIL 20
APRIL 30
ATLANTIC OCEAN
BAY OF FUNDY
EARLIER
SCALE
0
50
100
KILOMETRES
APRIL 20
APRIL 25
MAP 6

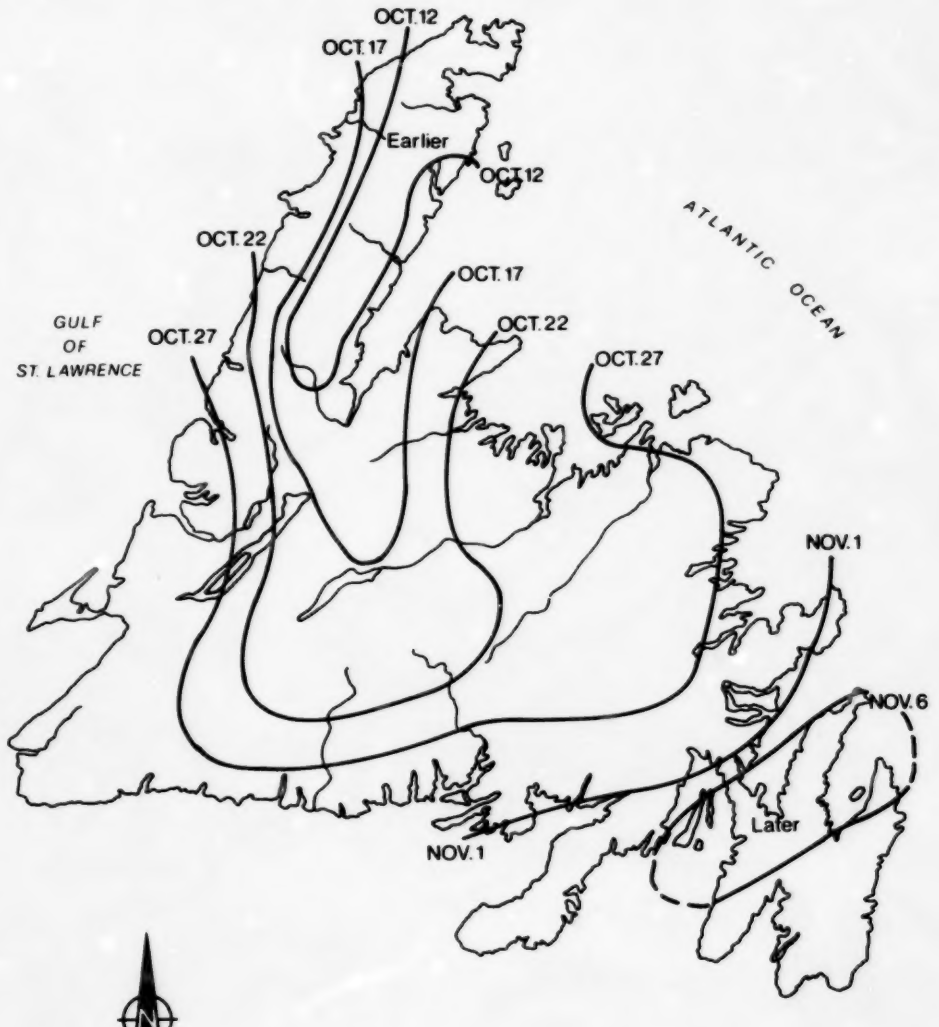
AVERAGE START OF GROWING SEASON (5°C)



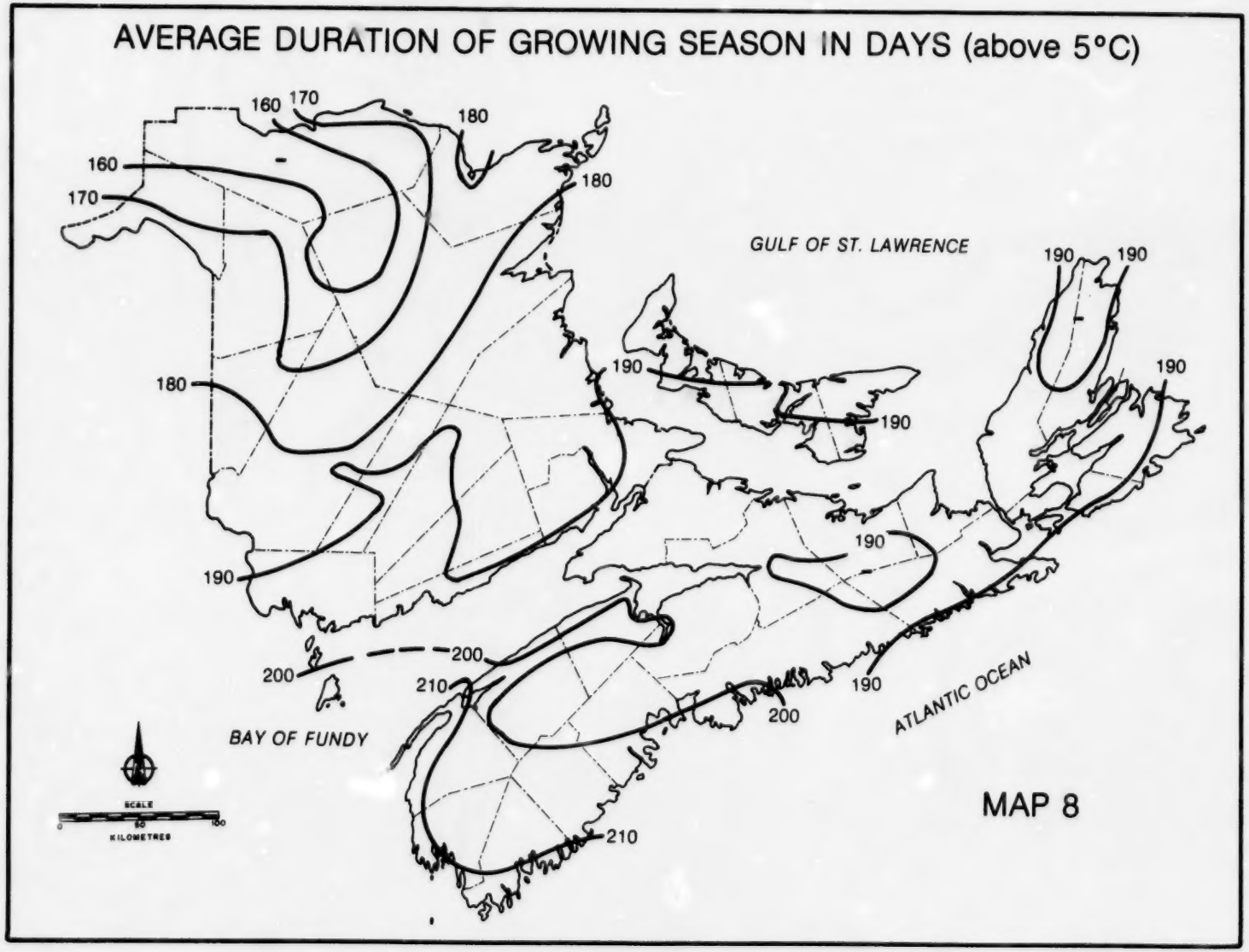
MAP 6a


AVERAGE END OF GROWING SEASON (5°C)
OCT 17
OCT 12
OCT 22
OCT 12
OCT 17
GULF OF ST. LAWRENCE
OCT 27
NOV 1
NOV 1
NOV 6
OCT 22
NOV6
NOV 11
OCT 27
NOV 1
NOV 6
NOV 11
ATLANTIC OCEAN
BAY OF FUNDY
SCALE
50
100
KILOMETRES
MAP 7

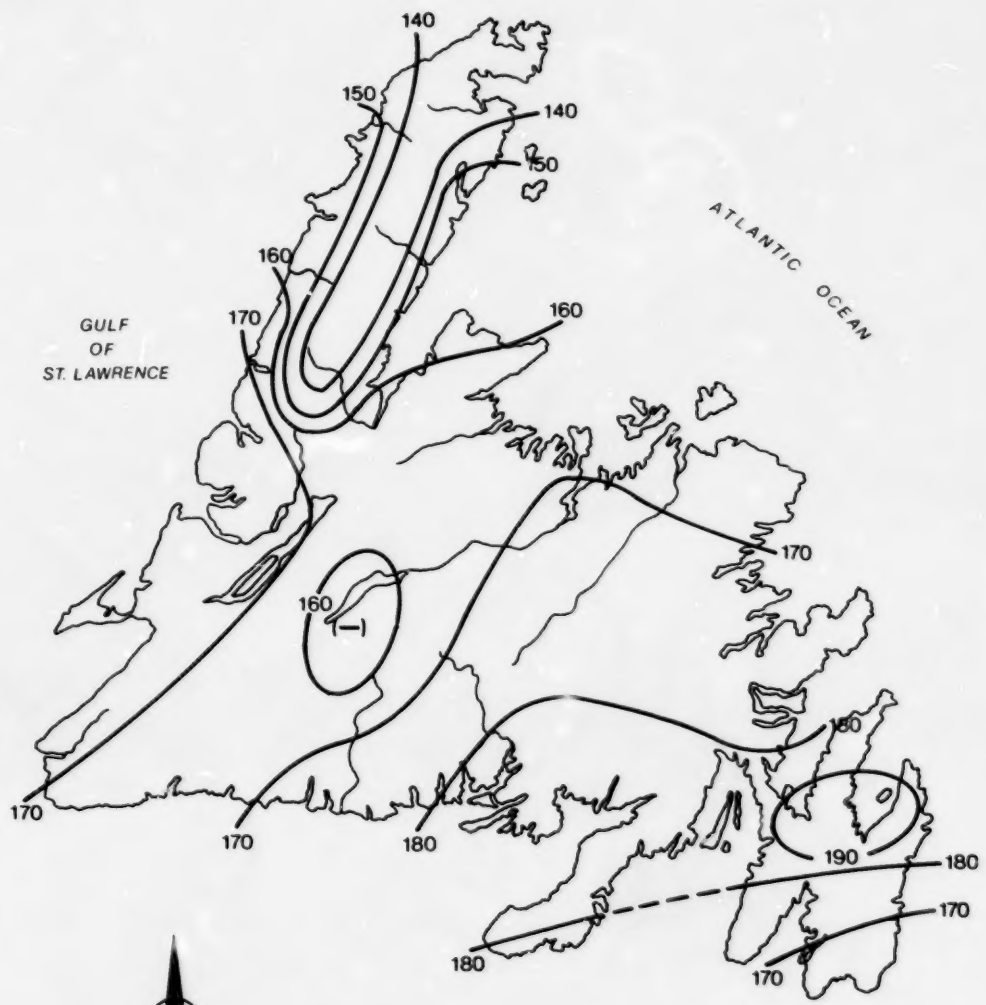
AVERAGE END OF GROWING SEASON (5°C)



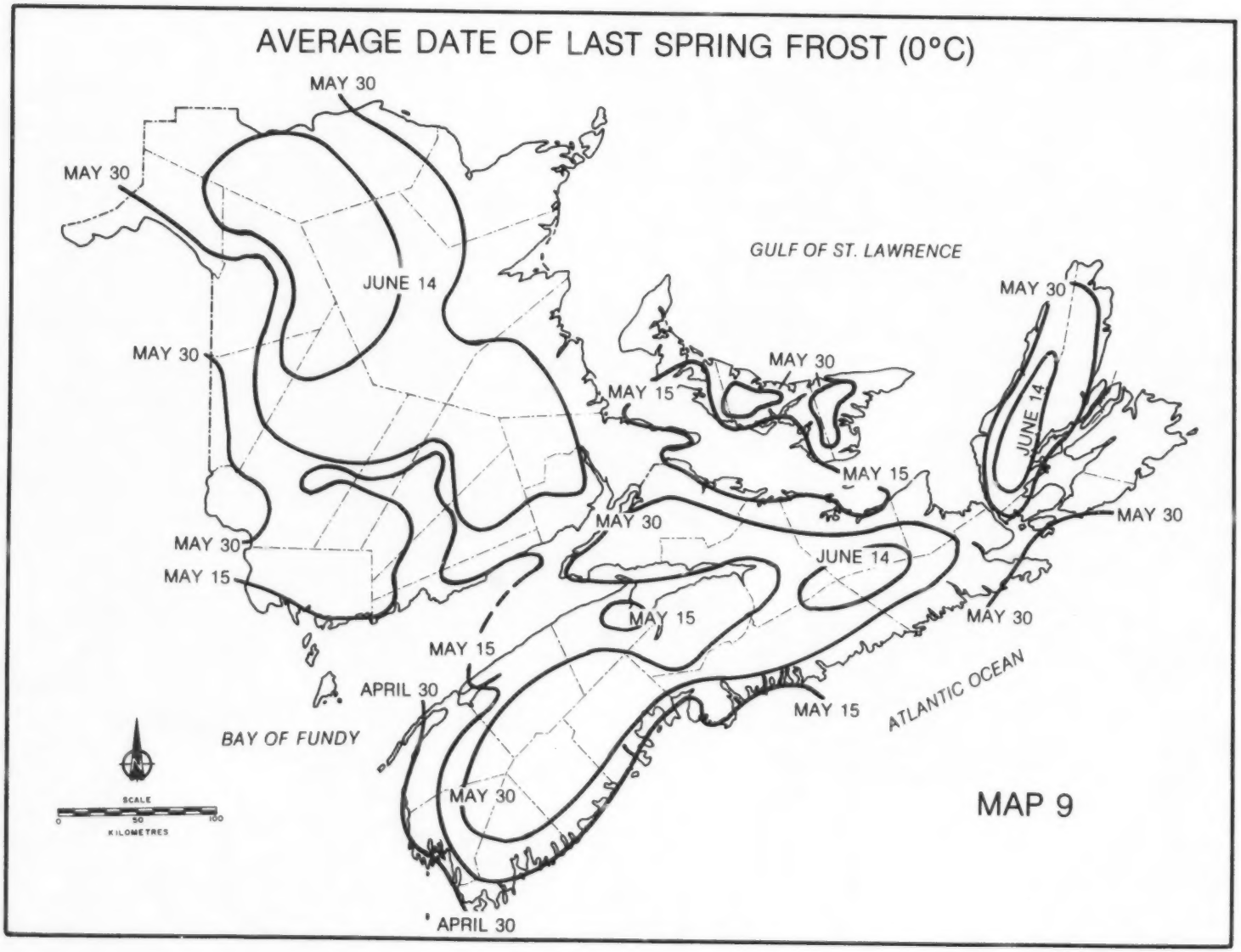
MAP 7a


AVERAGE DURATION OF GROWING SEASON IN DAYS (above 5°C)
160
170
180
160
170
180
180
GULF OF ST. LAWRENCE
190
190
190
180
190
190
190
190
200
200
210
200
190
ATLANTIC OCEAN
BAY OF FUNDY
210
SCALE
0
50
100
KILOMETRES
MAP 8

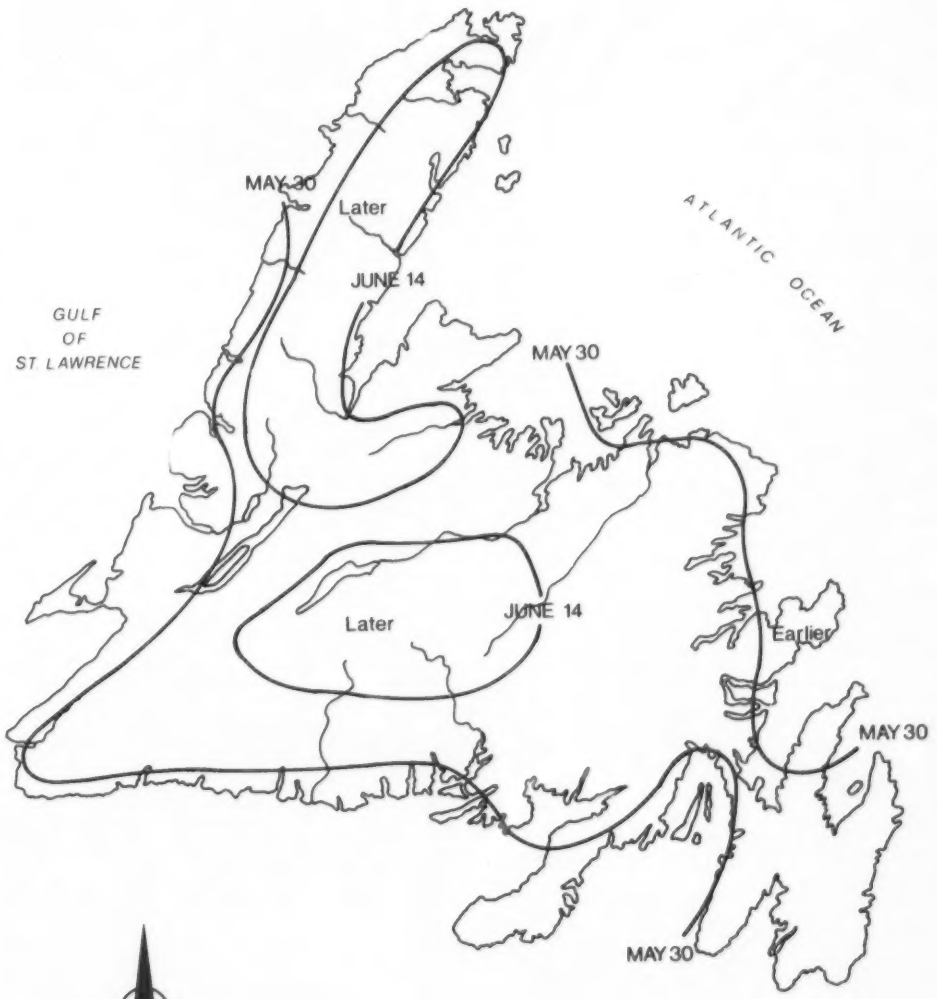
AVERAGE DURATION OF GROWING SEASON IN DAYS (ABOVE 5° C)



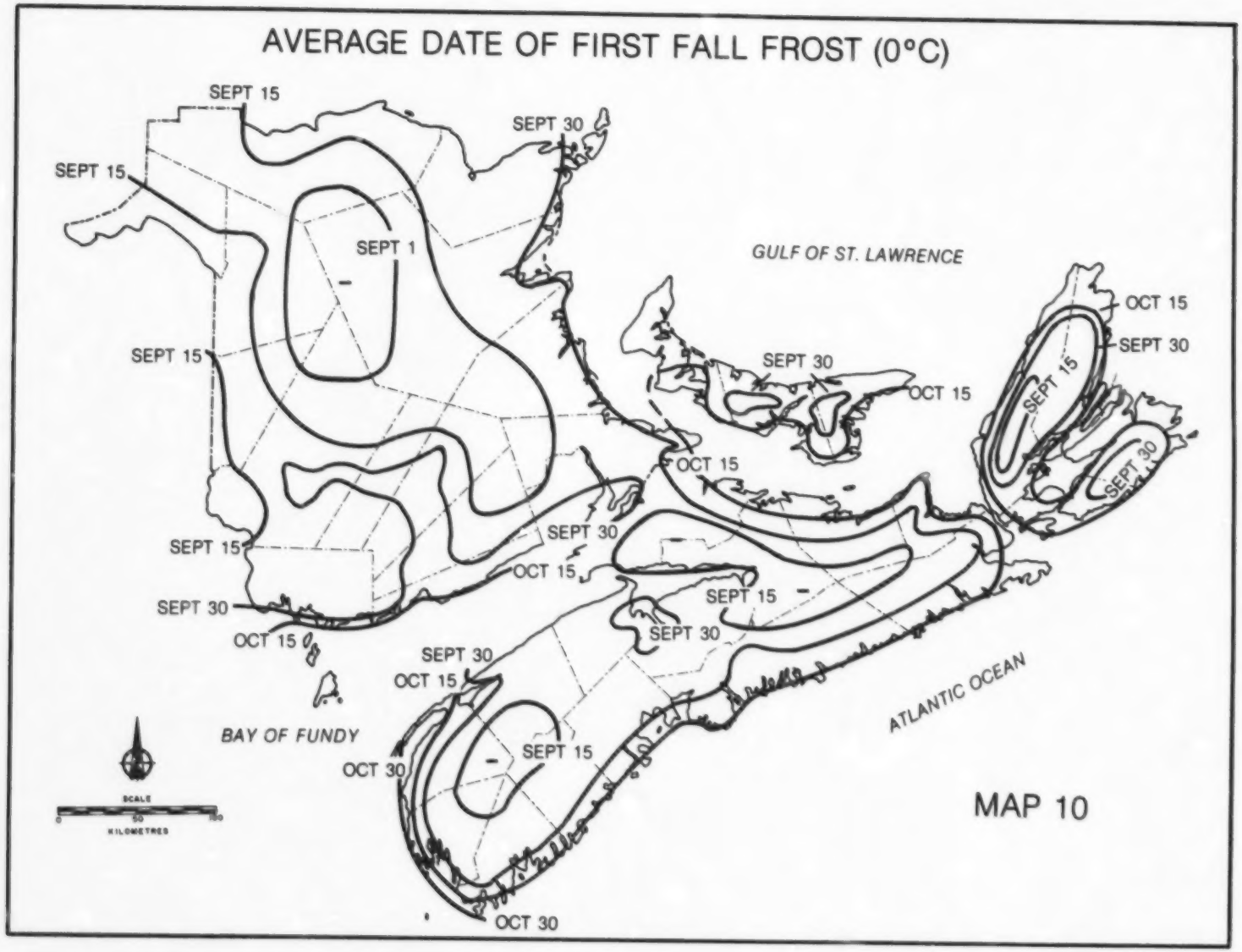
MAP 8a


AVERAGE DATE OF LAST SPRING FROST (0°C)
MAY 30
MAY 30
JUNE 14
MAY 30
MAY 30
MAY 15
GULF OF ST. LAWRENCE
MAY 30
MAY 15
MAY 30
JUNE 14
MAY 30
MAY 30
MAY 15
JUNE 14
MAY 30
MAY 15
MAY 15
APRIL 30
BAY OF FUNDY
MAY 15
ATLANTIC OCEAN
SCALE
0 50 100
KILOMETRES
MAY 30
APRIL 30
MAP 9

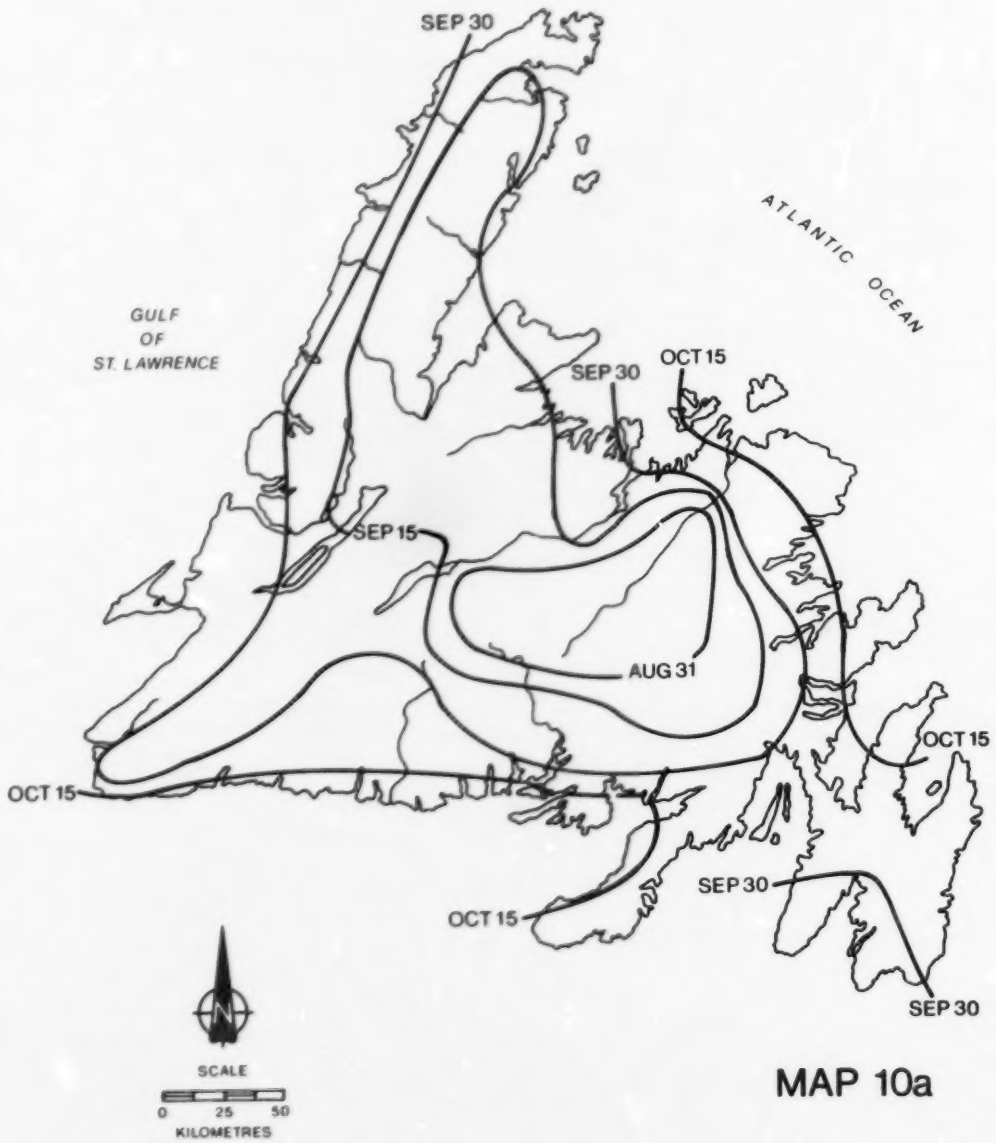
AVERAGE DATE OF LAST SPRING FROST (0°C)



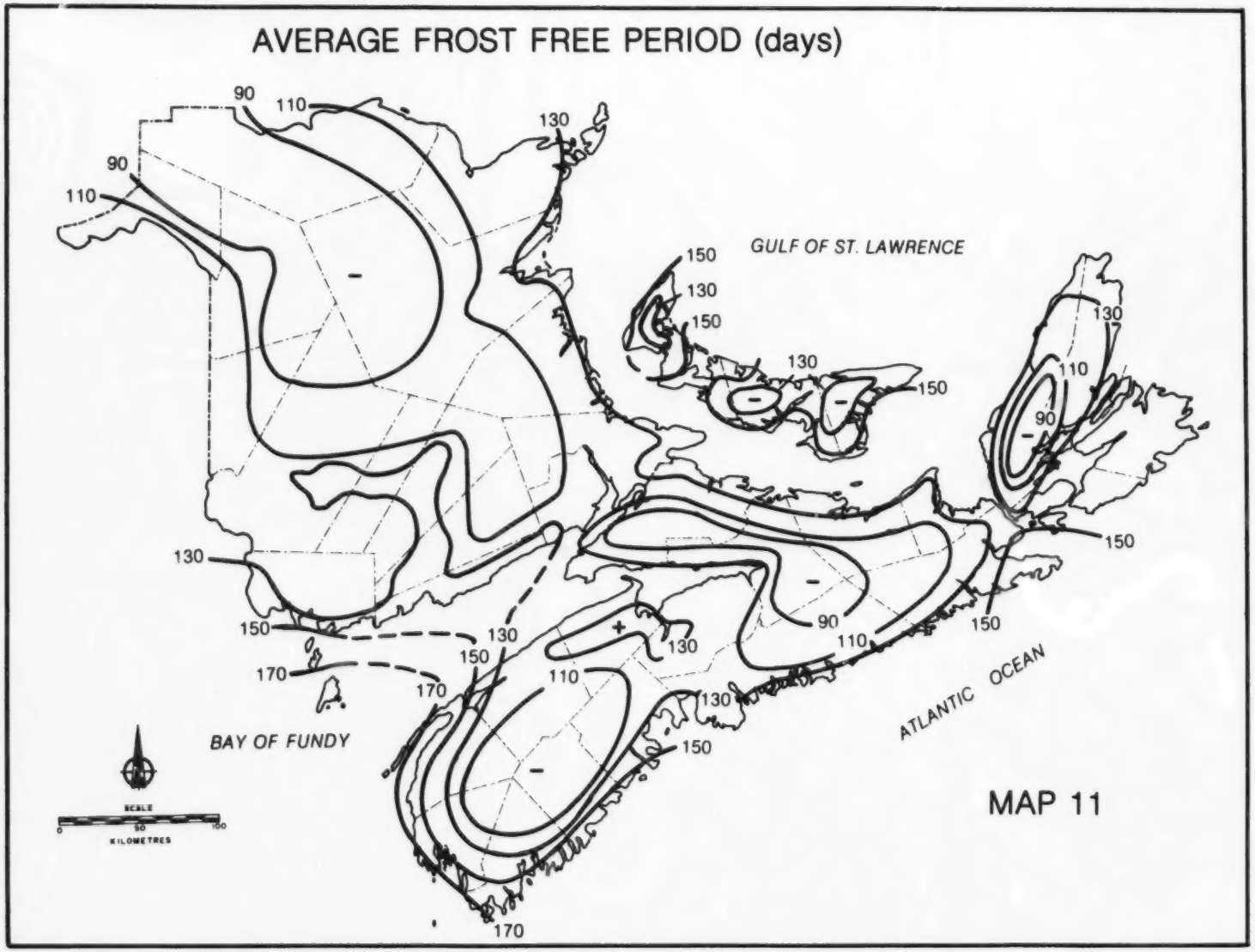
MAP 9a


AVERAGE DATE OF FIRST FALL FROST (0°C)
SEPT 15
SEPT 30
SEPT 15
SEPT 1
GULF OF ST. LAWRENCE
OCT 15
SEPT 30
SEPT 30
OCT 15
SEPT 15
SEPT 30
OCT 15
SEPT 15
SEPT 30
OCT 15
SEPT 30
SEPT 15
SEPT 30
OCT 15
SEPT 30
OCT 15
ATLANTIC OCEAN
BAY OF FUNDY
SEPT 15
OCT 30
OCT 30
SCALE
0
50
100
KILOMETRES
MAP 10

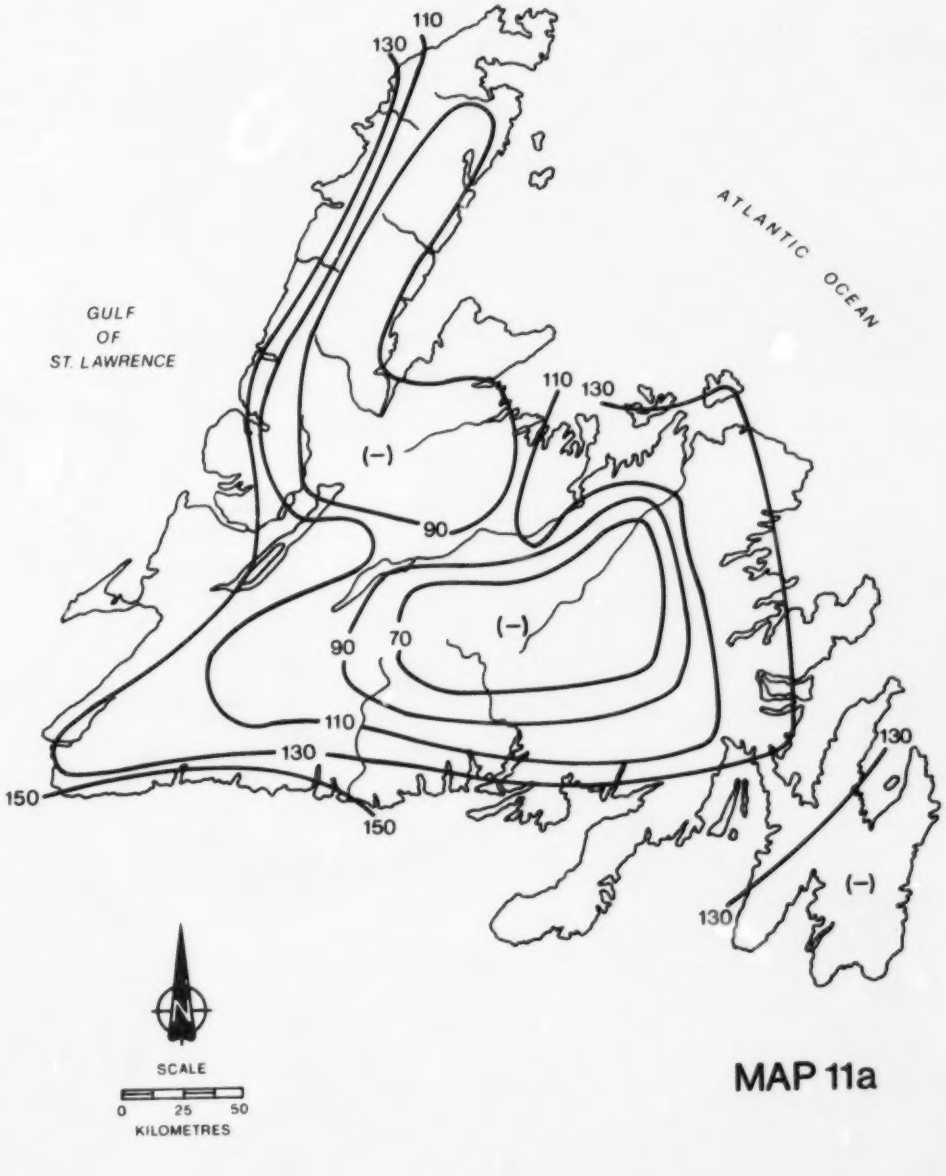
AVERAGE DATE OF FIRST FALL FROST (0° C)



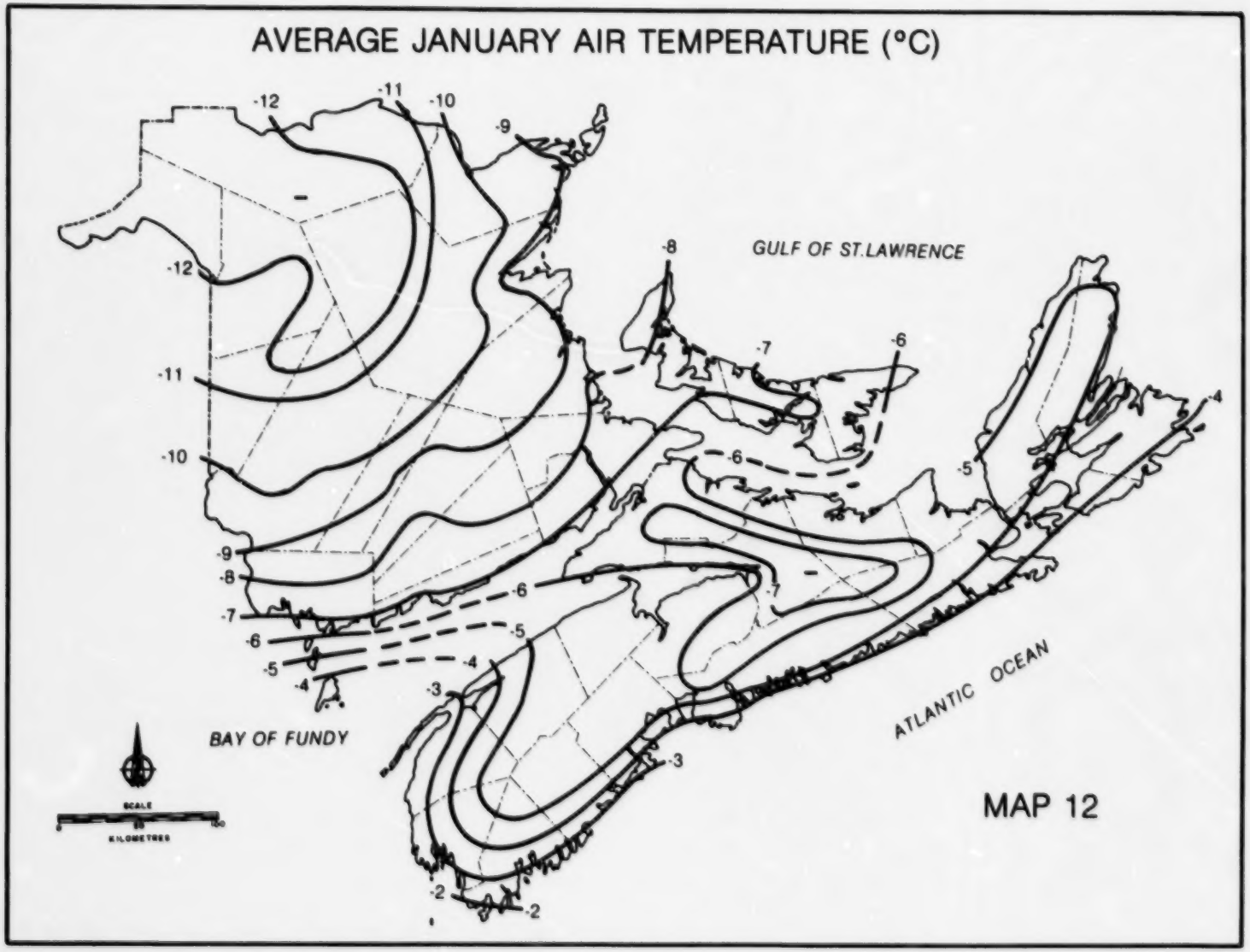
MAP 10a


AVERAGE FROST FREE PERIOD (days)
90
110
130
90
110
GULF OF ST. LAWRENCE
150
130
150
130
150
130
110
90
150
130
150
130
150
90
110
150
170
170
110
130
150
BAY OF FUNDY
ATLANTIC OCEAN
170
SCALE
0
50
100
KILOMETRES
MAP 11

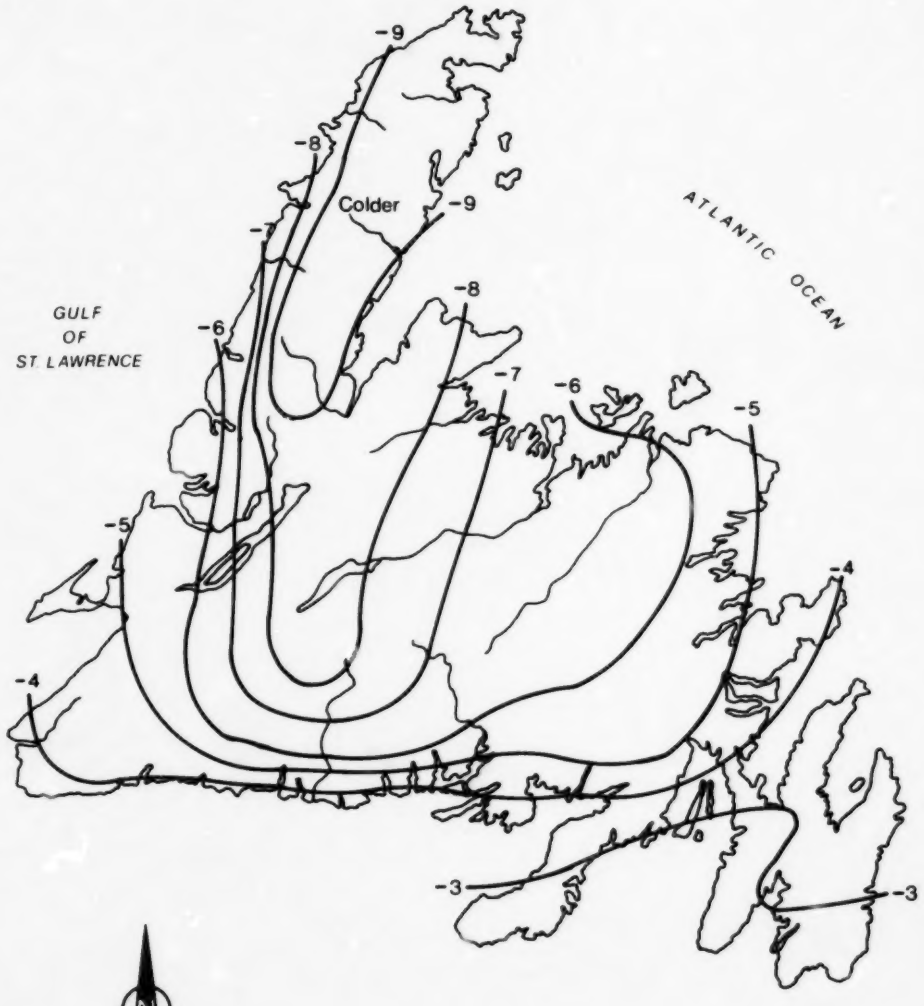
AVERAGE FROST FREE PERIOD (DAYS)



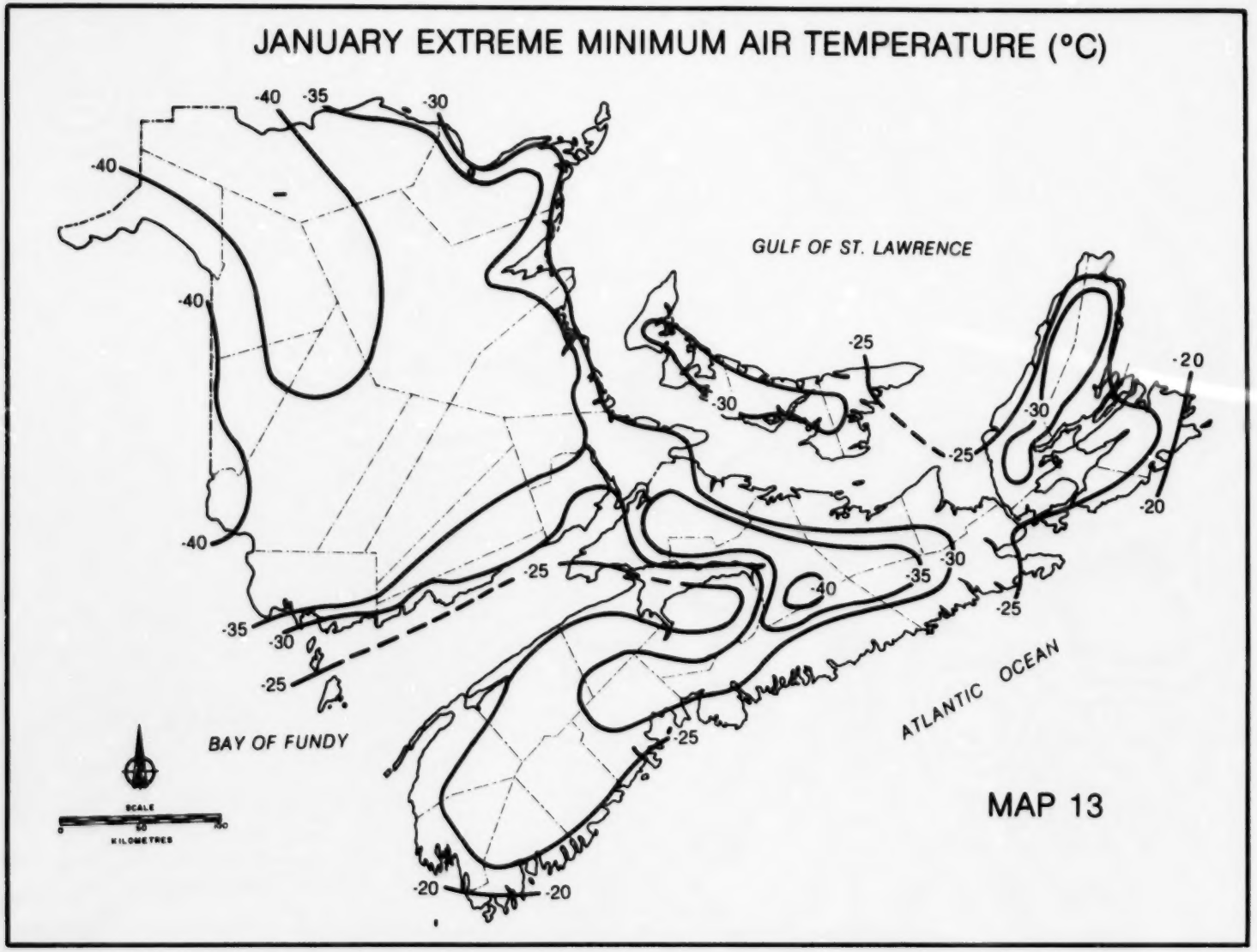
MAP 11a


AVERAGE JANUARY AIR TEMPERATURE (°C)
-12
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
GULF OF ST.LAWRENCE
BAY OF FUNDY
ATLANTIC OCEAN
SCALE
KILOMETRES
MAP 12

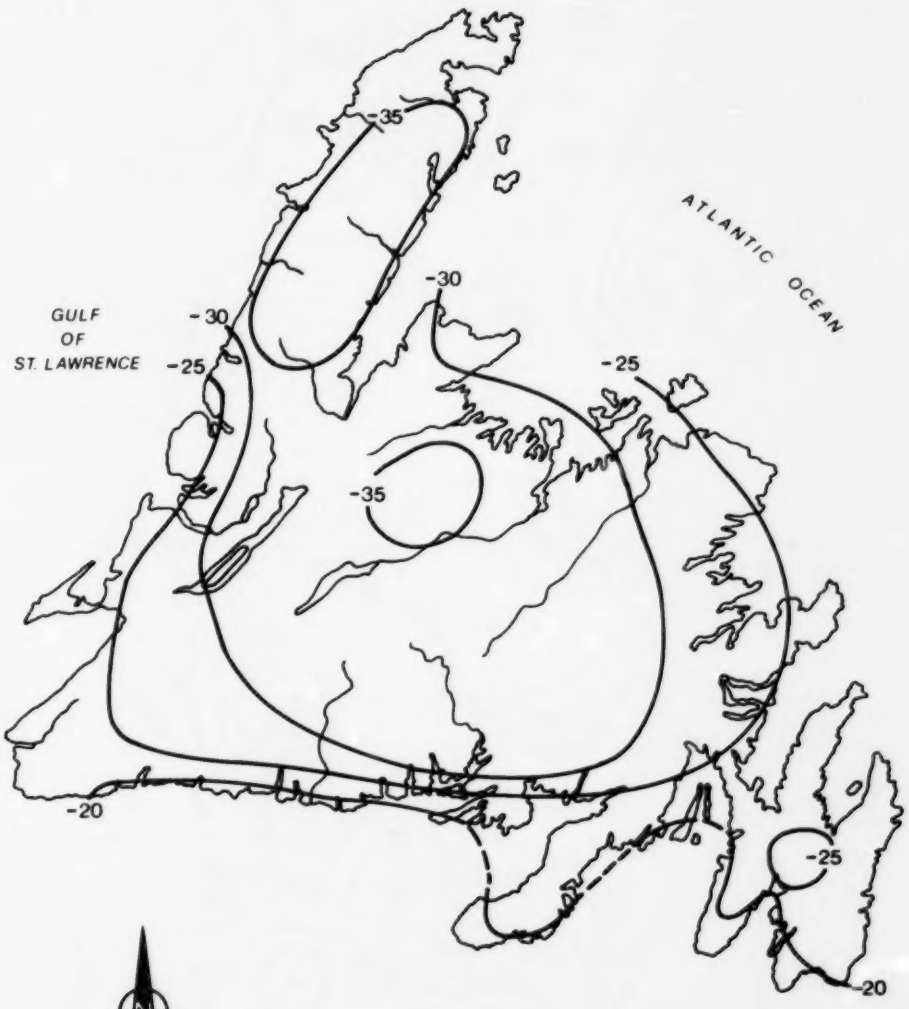
AVERAGE JANUARY AIR TEMPERATURE (°C)



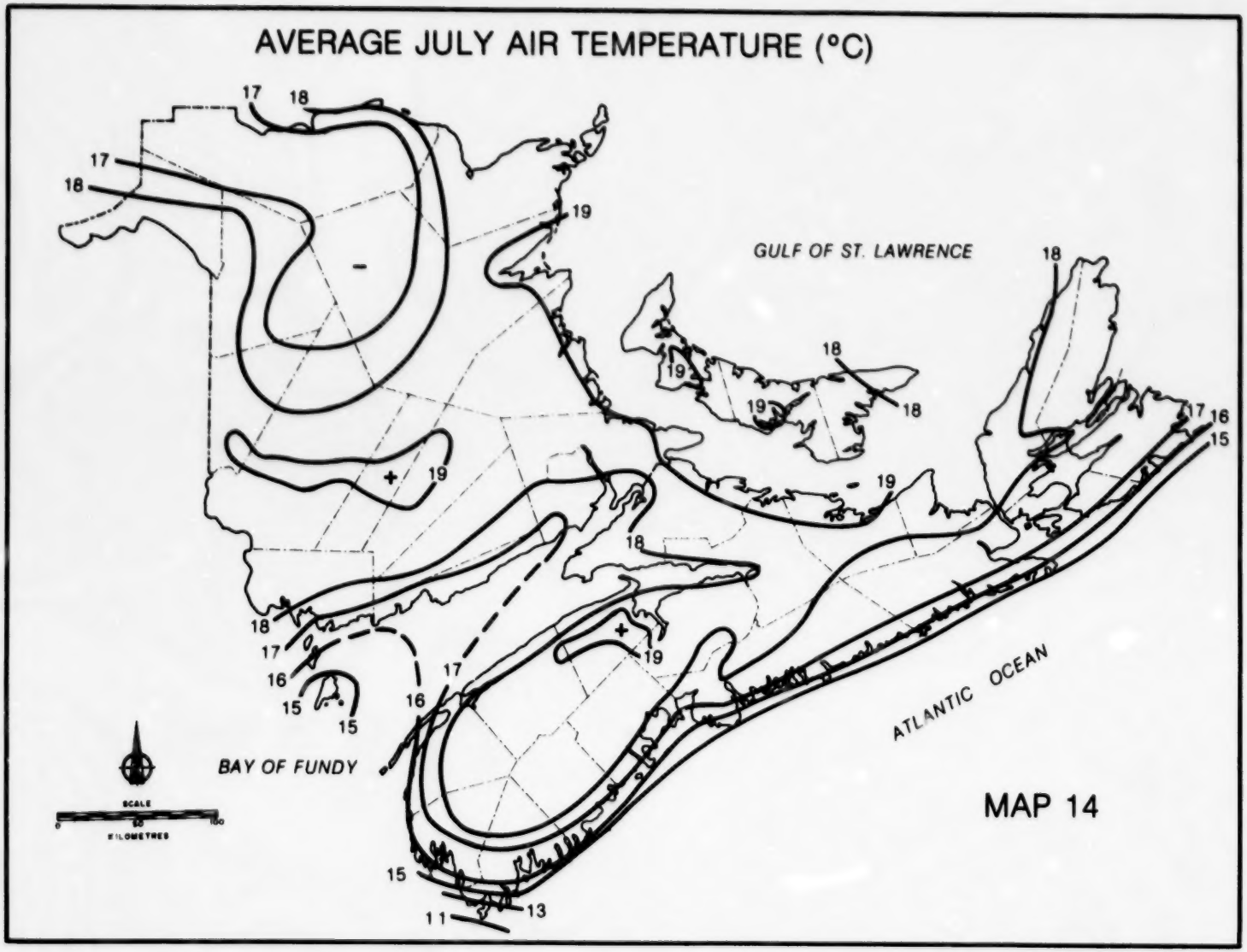
MAP 12a


JANUARY EXTREME MINIMUM AIR TEMPERATURE (°C)
-40
-35
-30
-40
-40
-40
-35
-30
-25
-25
GULF OF ST. LAWRENCE
-25
-30
-30
-20
-20
-30
-35
-40
-25
-25
BAY OF FUNDY
ATLANTIC OCEAN
-25
-20
-20
SCALE
0
50
100
KILOMETRES
MAP 13

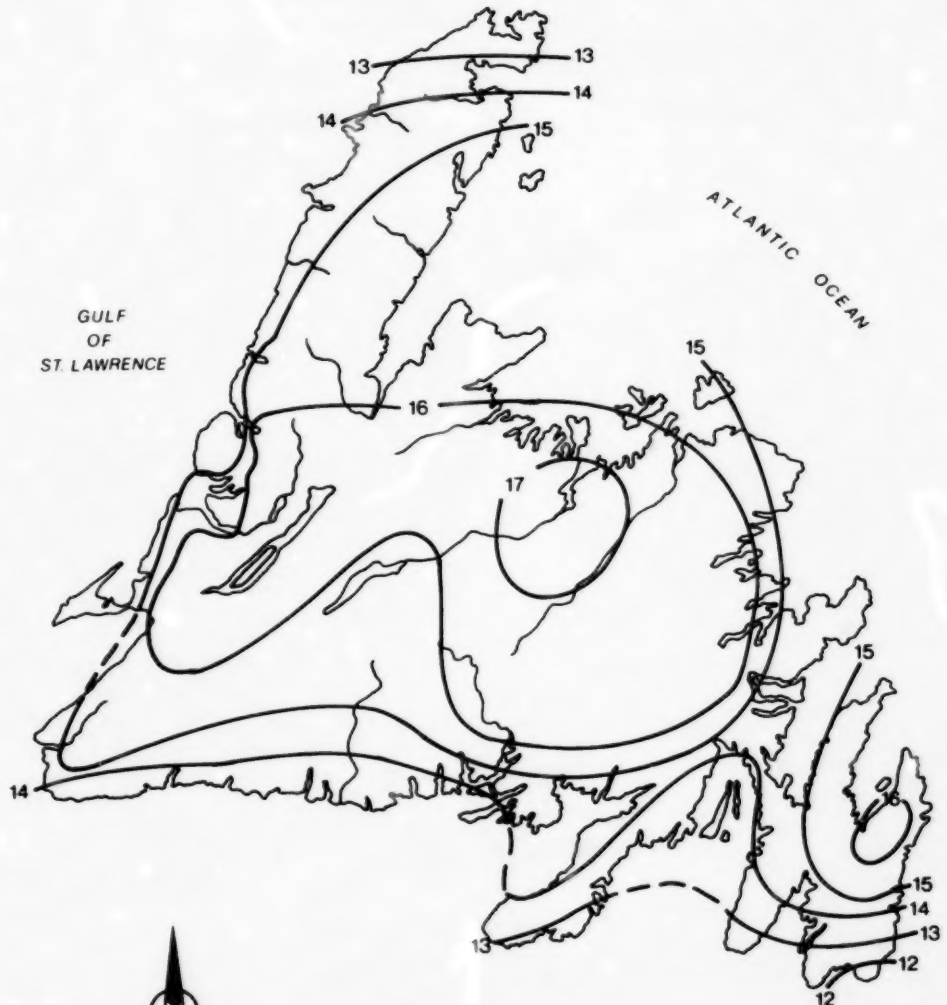
JANUARY EXTREME MINIMUM AIR TEMPERATURE
(°C)



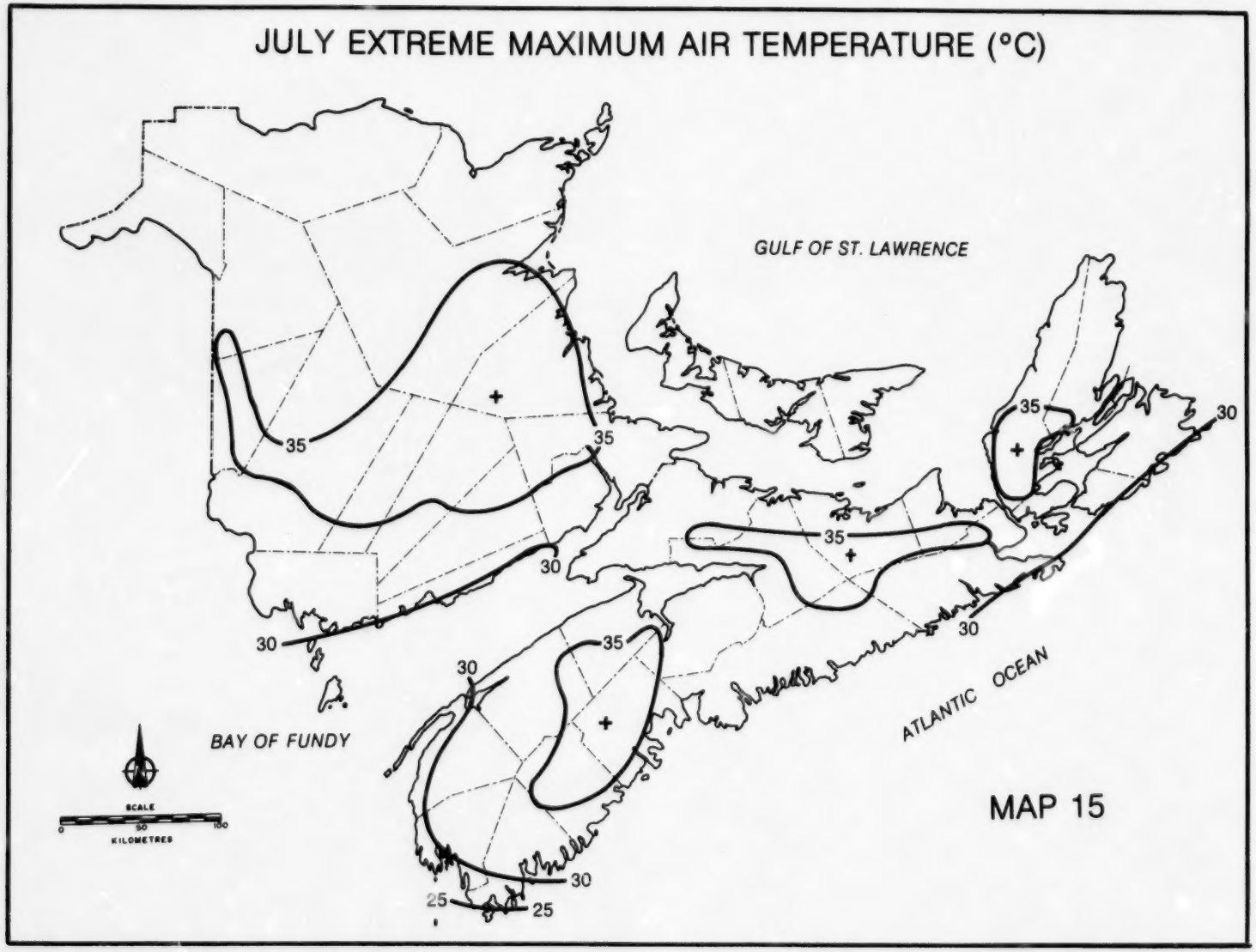
MAP 13a


AVERAGE JULY AIR TEMPERATURE (°C)
GULF OF ST. LAWRENCE
ATLANTIC OCEAN
BAY OF FUNDY
SCALE
KILOMETRES
MAP 14

AVERAGE JULY AIR TEMPERATURE (°C)

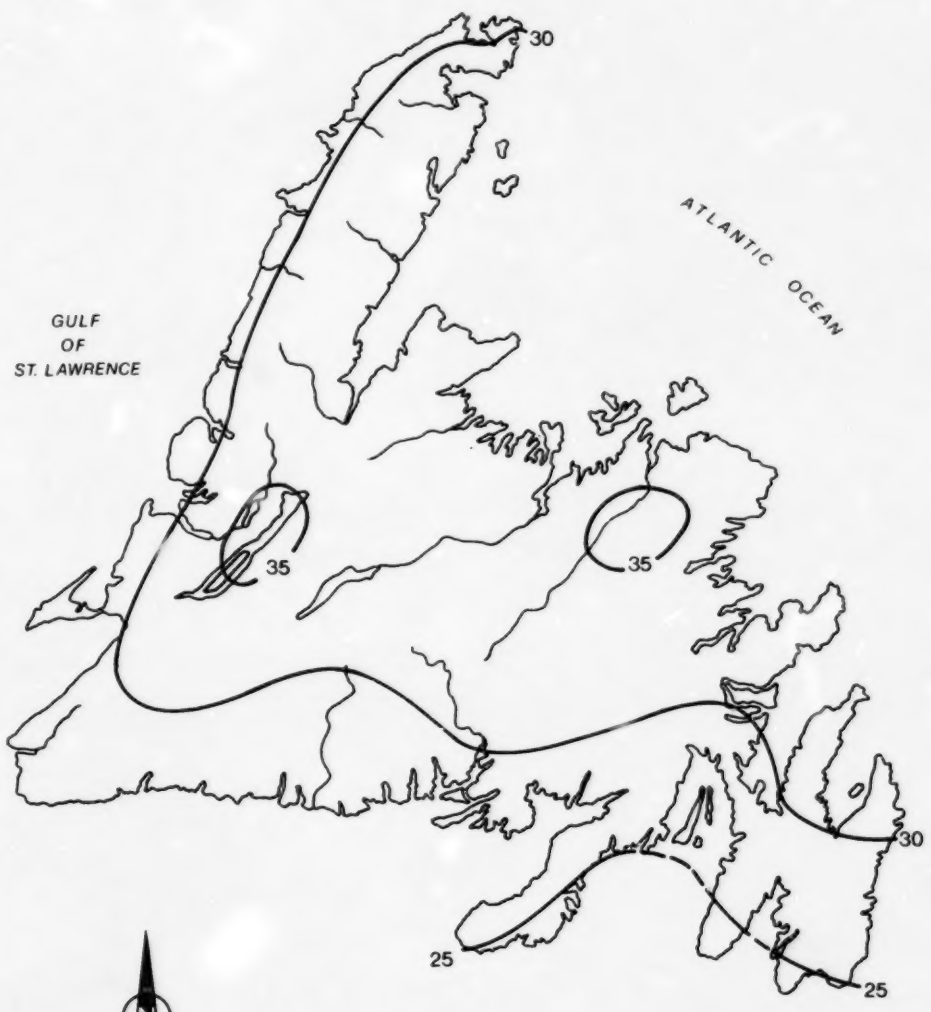


MAP 14a

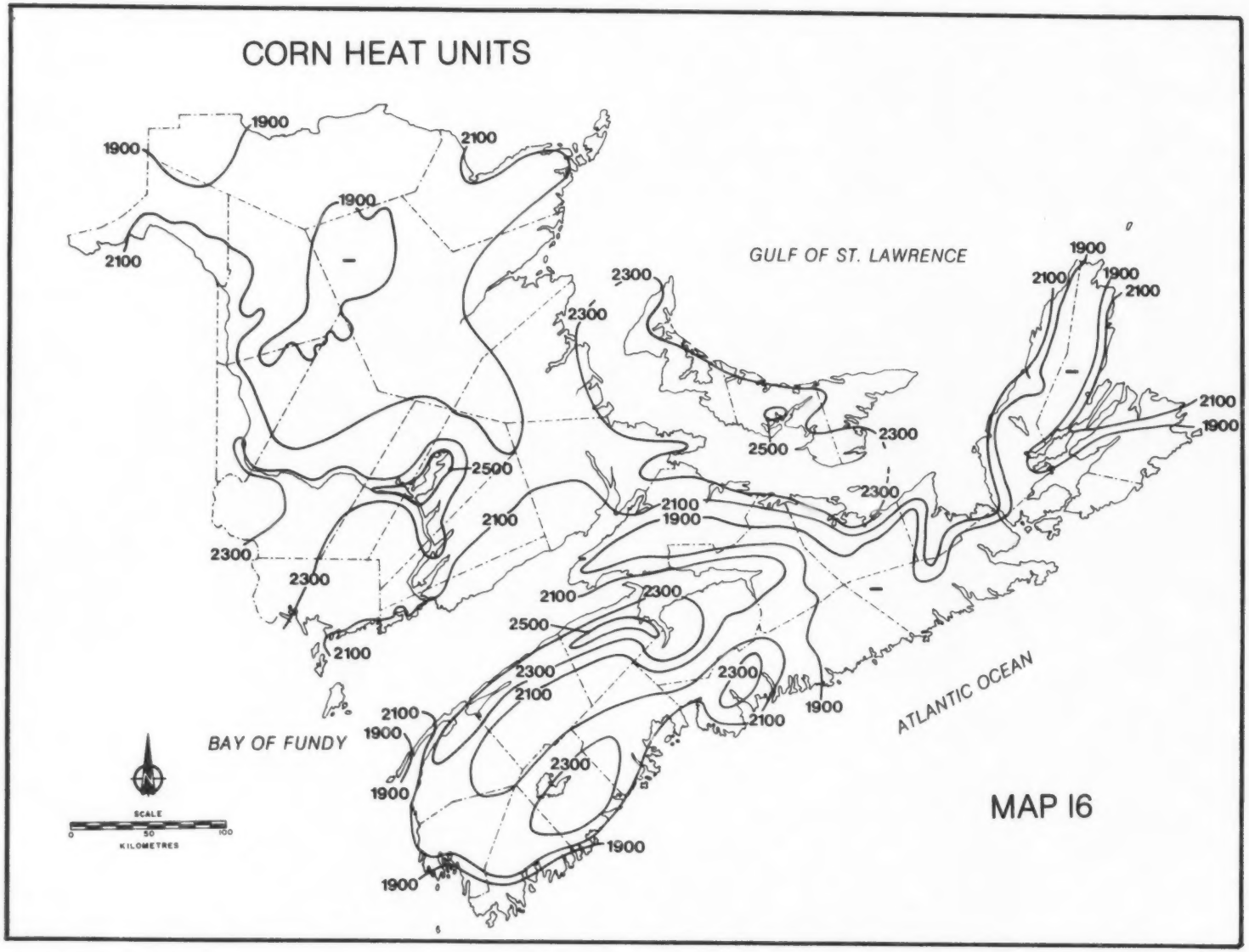

JULY EXTREME MAXIMUM AIR TEMPERATURE (°C)
GULF OF ST. LAWRENCE
BAY OF FUNDY
ATLANTIC OCEAN
35
35
30
30
35
35
30
30
35
30
30
25
25
SCALE
0
50
100
KILOMETRES
MAP 15

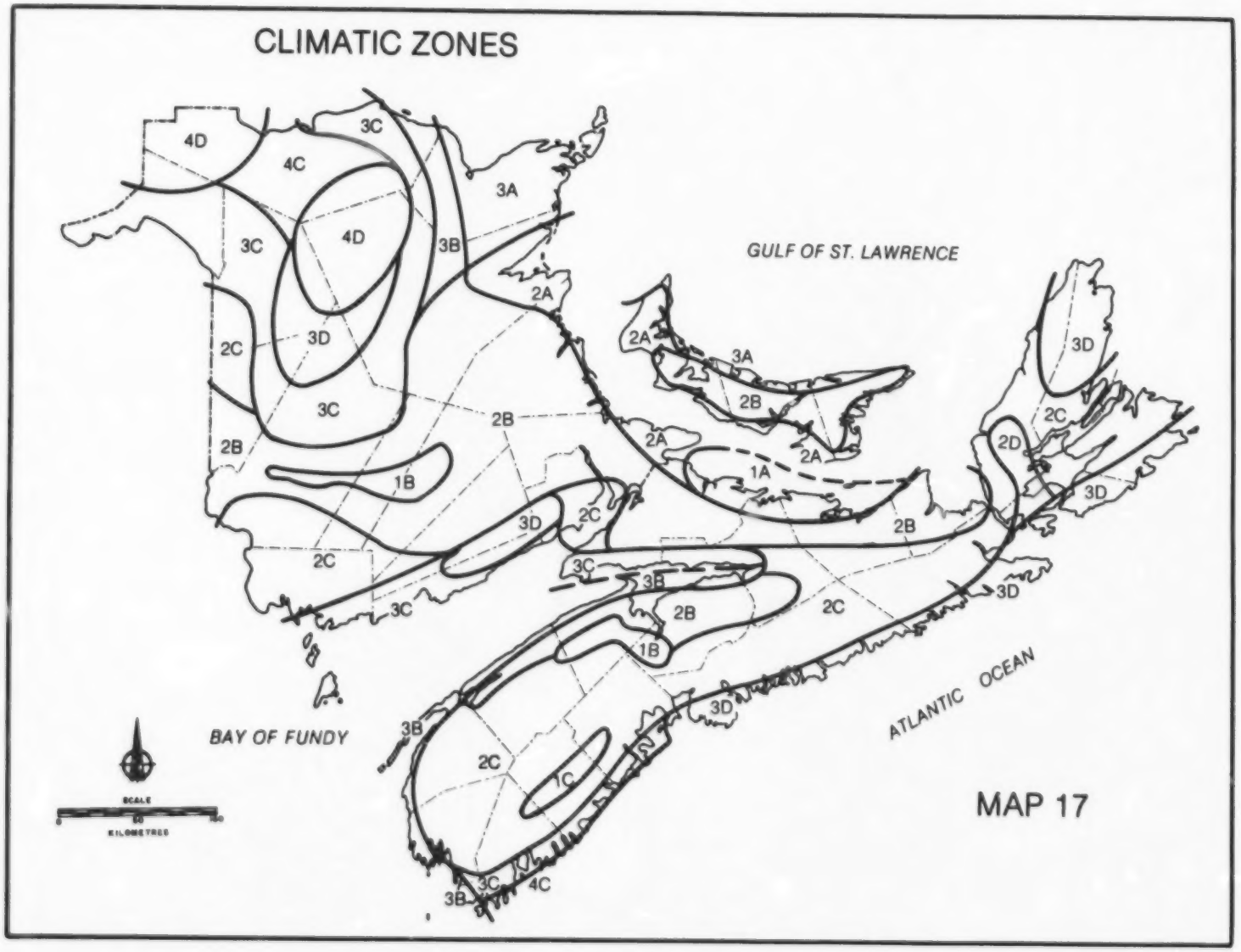
JULY EXTREME MAXIMUM AIR TEMPERATURE

(°C)

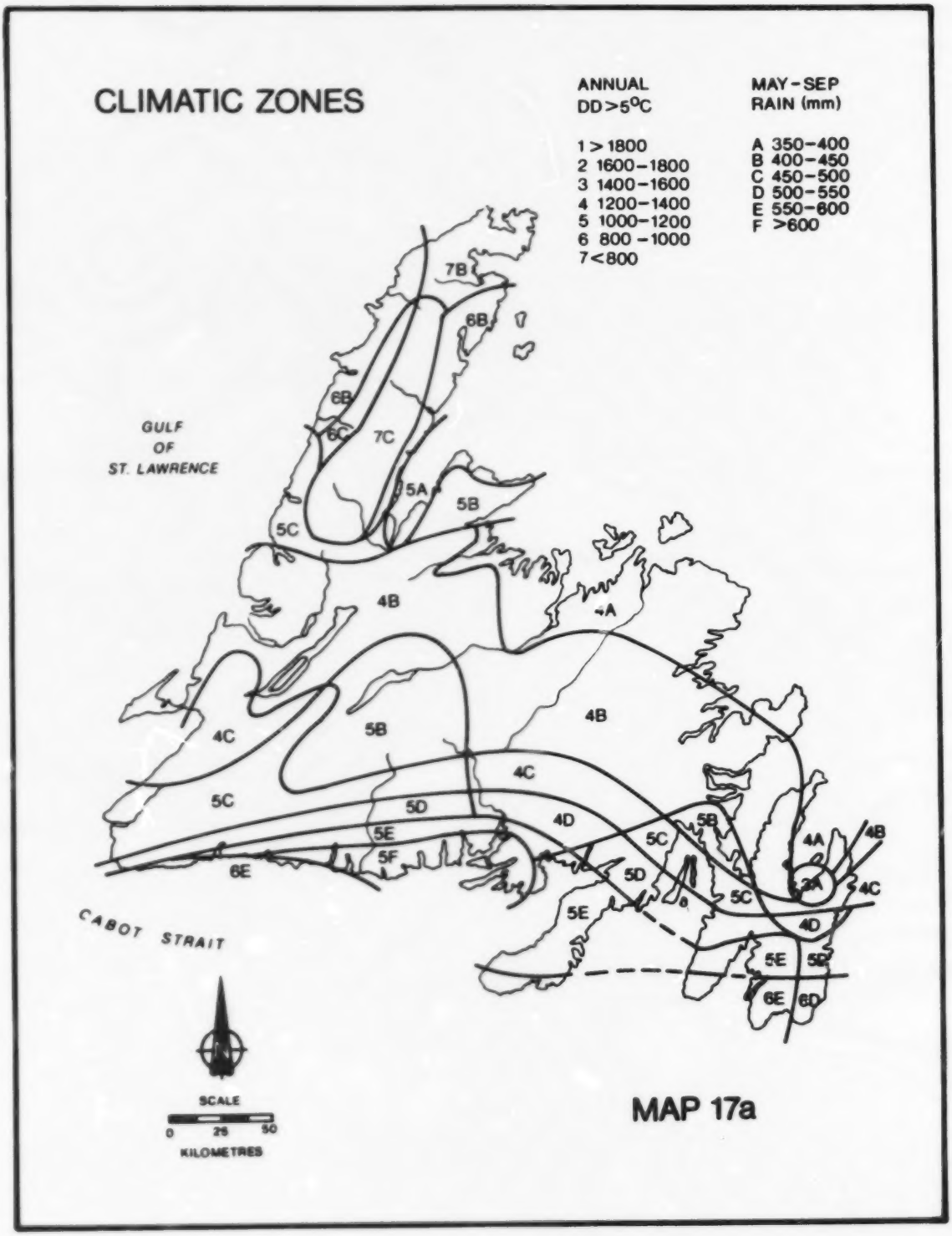


MAP 15a


CORN HEAT UNITS
GULF OF ST. LAWRENCE
BAY OF FUNDY
ATLANTIC OCEAN
MAP 16
SCALE
0 50 100
KILOMETRES
1900
2100
2300
2500


CLIMATIC ZONES
4D
4C
3C
3A
3C
4D
3B
GULF OF ST. LAWRENCE
2A
2C
3D
2A
3A
3D
3C
2B
2B
2C
2A
2D
2B
1B
2A
1A
3D
2C
3D
2C
2B
3C
3B
3C
2B
2C
3D
1B
BAY OF FUNDY
3B
3D
ATLANTIC OCEAN
2C
1C
3B
3C
4C
SCALE
KILOMETRES
MAP 17

CLIMATIC ZONES



MAP 17a